THE GLASS INDUSTRY
VOLUME 16, NUMBER 8, AUGUST, 1935

RESULTS VIA SCIENTIFIC CONTROL

A problem in glass making. How it was solved. And the results obtained.

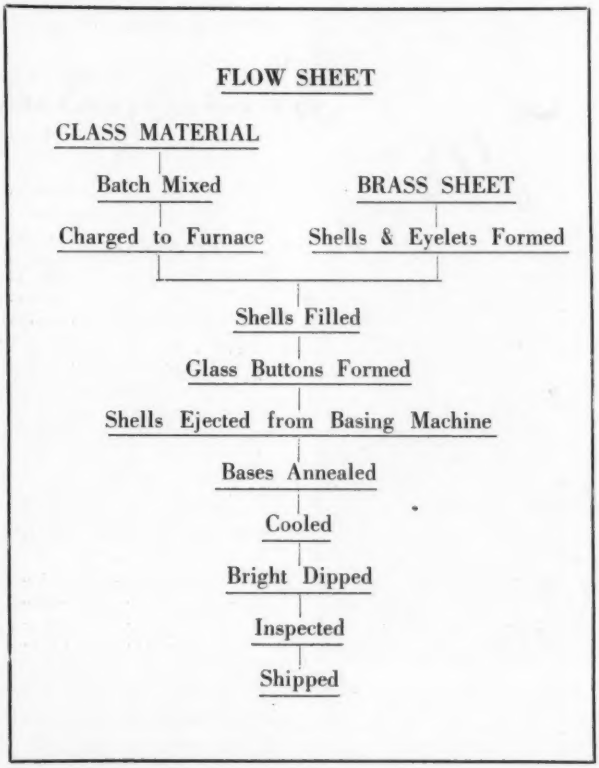
By H. K. RICHARDSON
Westinghouse Lamp Company

THE black insulation at the end of incandescent lamp bases is glass. The control of the method by which this glass is placed into the brass shell has recently undergone some revolutionary changes. Formerly, the process was wholly in the hands of the operator. Continuous operation of the process depended entirely upon his skill and training. Now it has become one of the best controlled of present-day glass processes. The latest information on glass batches, furnace refractories, and methods of temperature control are coordinated into a smooth-running whole which is well in the forefront of scientifically controlled processes. Changing from a "rule-of-thumb" method to one of scientific control has reduced shrinkages to less than 0.5 per cent, increased production, and improved quality.

The outline of the process is given in the accompanying chart.

A Geneva index machine of marvellous ingenuity, and known as the Glass Base Machine, performs the glass operation (Fig. 1). Some of these machines index at the rate of 220 per minute, and were the fastest operating glass working units until the advent of the Corning ribbon machine making 400 bulbs plus, per minute.

The development of the glass basing machines far outmoded glass handling methods. Since the product is relatively inexpensive, (from $4.00 to $10.00 per thousand) all processes were necessarily simple. Only processes of low cost were considered. With the manufacture of 360,000,000 incandescent lamps in 1934 —each requiring a base—the total number of pieces in one year's production is obviously large.



Temperature Control Important

A few years ago, the demand for increased quality at a reduced cost became so insistent as to necessitate a thorough study of glass handling processes. As was to be expected, temperature control of the flowing glass stream was of greatest importance. With the die set-up then in use, however, it was impractical to maintain constant temperature. The orifice, or die, through which the glass flowed, was made of hard-burned, electrical porcelain with the funnel glazed. The erosive action of the stream enlarged the orifice almost from the start. In order to obtain a constant discharge of glass in the face of these obstacles, the operators had to change the temperature of the glass stream at frequent intervals.

When the stream became too cold for use, the furnace was shut off and a ceramic plug (like a grooved feeder plug) was dropped into the top of the orifice. It acted as a valve that reduced the effective orifice and the stream size. The temperature of the glass was then raised. As the groove in the plug wore away, the temperature was again reduced as with a new die. This operation was repeated about every 50 hours when a highly skilled operator was in charge, many more times with a less-skilled operator.

Sometimes it was impossible to control the glass flow with tempera-

ture alone because the oil burner which heats the furnace serves the dual purpose of heating the charge in the rear of the furnace while also keeping the charge hot at the front of the furnace over the die. To overcome this obstacle to temperature control, the operator would now and then toss a little extra soda ash or sand into the batch. But, of course, this also added to the operating variables. But after a time trouble would accumulate to such a degree that the furnace had to be shut down altogether and started afresh with a new batch. During all these manipulations the operator could, and did, vary the speed of the Glass Base Machines to obtain a definite thickness of glass in the base.

These troubles were eliminated largely by the use of a die of unvarying diameter. It was made with a platinum-rhodium lined refractory. A method of temperature control, using a radiation pyrometer sighted on the flowing stream, was developed so that only minor variations in the stream temperature are now encountered*.

Many by-products evolved from this work. Many of the improvements are already known to skilled glass engineers, while others are new. Although applied to a very small scale process, they serve to illustrate what can be done to improve a condition when available knowledge is applied.

Use Two Batches

Each size and type of base (some fifteen in all) was originally served by a special glass formula all its own. Actually, since the operator could juggle the composition to suit his conditions, the number of batches in use for all intents and purposes was infinite. As temperature control was perfected, the number of batches was gradually reduced until now only two are in use. These are:

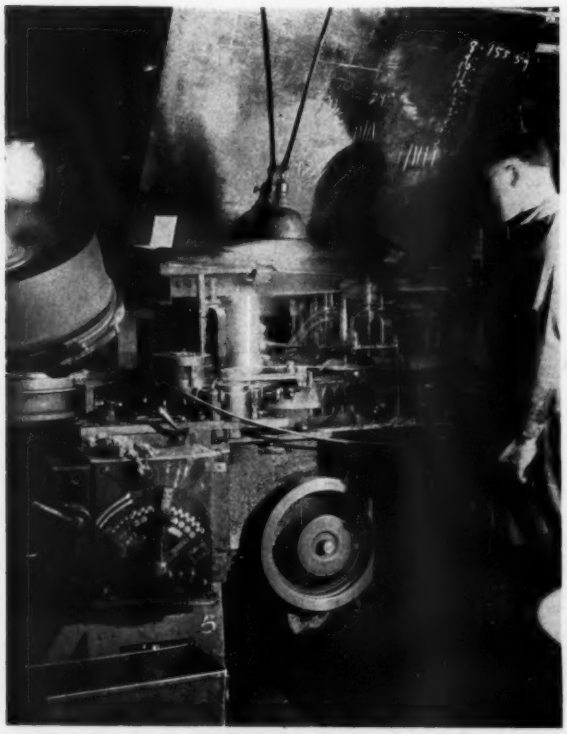
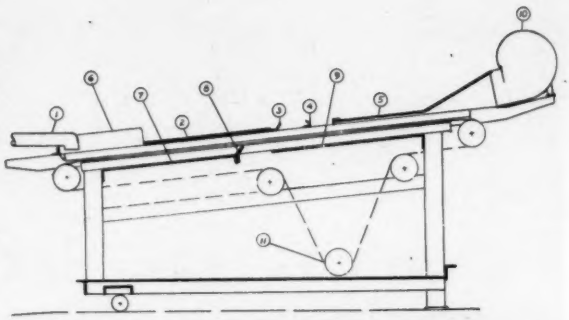
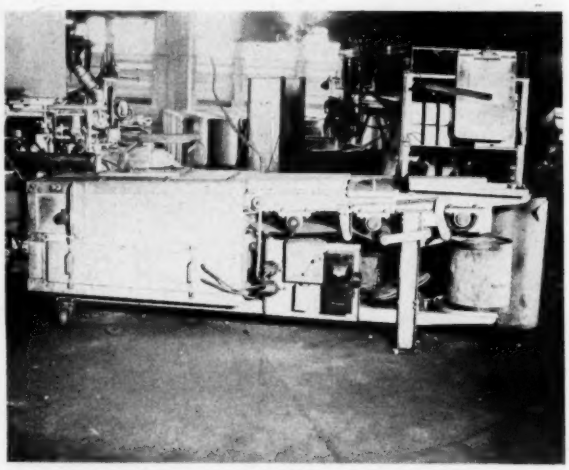


Fig. 1. Closeup of a basing machine, which operates at approximately 200 indexes per minute. Note the small stream of glass under the furnace. Bases are discharged to the annealer through the tube at the operator's right.





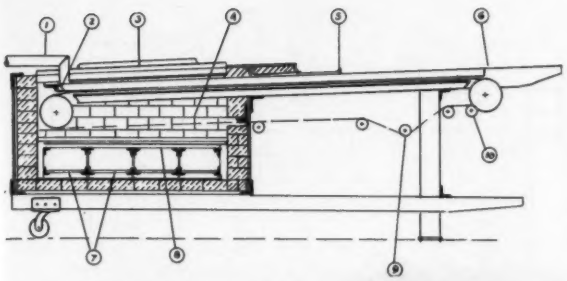
(Below) Fig. 3. The heatless conveyor, in which the bases are cooled by air blast after passing through a closed section where the heat from the bases preserves their temperature briefly. Above (Fig. 2) a diagramatic sketch of the conveyor showing (1) discharge tube, (2) cover of annealing section of lehr, (3, 4, 7, 8, 9) deflectors to prevent drafts from cracking hot bases, (5) air blower section for rapid cooling, (6) open end receiving section of lehr, and (11) idlers.

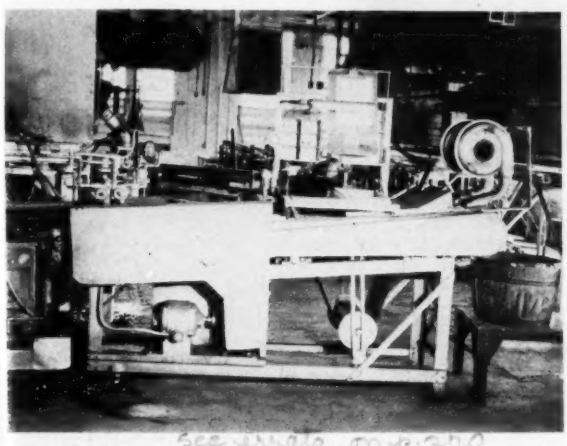
	FORMULA "A" lbs.	FORMULA "B" lbs.
Sand	0	144
Soda Ash	0	108
Bulb Glass	392	300
Potassium Bichromate	2	0
Manganese Dioxide	9	33
Cullet	50	0
Ammonium Sulphate	2	0
Totals	455	585

The calculated compositions which are very close to the actual analysis are:

	FORMULA "A" %	FORMULA "B" %
SiO_2	70.7	65.8
R_2O_3	1.3	1.0
Na_2O—K_2O	16.2	21.5
CaO	4.9	3.0
MgO	3.1	1.0
PbO	1.5	.9
MnO_2	2.0	5.9
Cr_2O_3	.3	0

Formula "A" is used for over 90 per cent of the bases. Note the absence of new material, except coloring matter, and the large amount of cullet (98 per cent). Formula "B" has over 55 per cent cullet.





(Below) Fig. 5. The Heated Conveyor. This is used for bases having a relatively large amount of brass in the glass, which cools the glass too quickly. To overcome this, the ejected base passes through a heated section on a lot belt, which retards cooling until the glass is partially annealed. (Above) Fig. 4 a diagramatic sketch of this conveyor showing (1) discharge tube, (2) deflector plate, (3) heated section of lehr, (4) oven for heating belt, (5) variable cover for adjusting annealing time, (6) discharge belt, (7-8) electric heating units, and (9-10) idlers.

Fortunately a good supply of lime glass cullet is available from the sealing-in process in our incandescent lamp assembly plants. Coming from a bulb blowing process which requires carefully controlled glass on a large scale, this cullet—called bulb glass—is uniform. However until ammonium sulphate was added to the batch, it was difficult to melt down all cullet batches. Now, with only 4 lbs. of ammonium sulphate per 1,000 lb. batch, the melting is extremely satisfactory.

Besides being easier to melt, the all-cullet batch (Formula "A") is much more uniform because mistakes in weighing, except the coloring material Bichromate and Manganese Dioxide, have little effect on the ultimate composition. Since these constitute only 3 per cent of the batch their control is not difficult. The use of Bichromate reduces the amount of Manganese needed for a definite color and also serves to stabilize the color so that wash-outs are fewer when combustion turns accidently, to the reducing side which now very rarely happens. The ammonium sulphate also may have a similar oxidizing effect.

Batches are charged intermittently to each furnace. No simple automatic method has been found to take care of this item, although several have been tried. Because of the positive pressure in the furnace, (2.5 inches of water column) the operation of such a device is difficult and since it would cost more than the whole furnace, the hand method is still in use.

Annealing Glass-Filled Bases

The hot brass shell with its quantity of formed glass was originally blown off the base machine into a ventilated pan to cool. As a result the brass shells softened and the glass cracked. The varying temperature of the ejected bases also made annealing a precarious process.

To be annealed properly, the glass should theoretically be held at about 525°C for 5 to 10 minutes. But if brass is held at this temperature for this length of time it gets too soft for use as a screw base. To get around this condition, a compromise is necessary. First, the glass had to be annealed just enough to keep it intact when subject to the soldering or arc welding of leads in the lamp assembly process. Second, sufficient hardness was kept in the brass to prevent its deformation in subsequent operations.

After the development of the glass stream temperature control, thereby allowing the glass base machine to operate at approximately a constant speed and temperature, the ejected bases started the cooling process at a uniform temperature. The present processes are built around definite annealing lehrs of which there are two general types, namely:

(1) Heatless Conveyors, in which the cooling of the bases is controlled to effect the proper compromise between glass and brass annealing.

(2) Heated Conveyors, in which the base is brought to a definite temperature and then the cooling controlled.

Heatless Conveyors (Figs. 2 and 3) are used for standard large bases. The hot base is discharged into the open end of the conveyor belt, stays in the open a short time, then passes under a closed section where the heat from the bases preserves their temperature for a short period. After the base has emerged from the covered section, the ordinary draft of air quickly reduces the brass temperature. When cooled below the temperature at which the brass will soften, the discharged shell is dropped into a keg and is allowed to cool down to room temperature before being finished by bright dipping.

Heated Conveyors (Figs. 4 and 5) are used for those bases where relatively large amounts of brass are in the

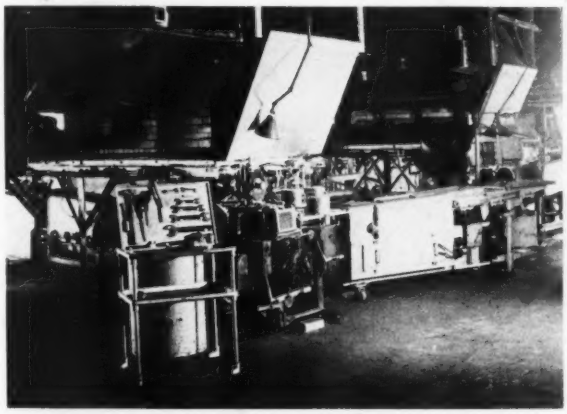


Fig. 6. General view of furnace, basing machine and annealer. Bases are filled under the glass furnace (left), blown into the closed annealer (right) through the discharge tube in the center, then pass to the extreme right and are dumped into a container.

glass. The double contact automobile headlight base is the best example of this type. The large amount of brass cools the glass too quickly. A hot belt must receive the ejected base and retard its cooling until the glass is partially annealed. A heated section to the lehr, required by the hot belt, does two things. It heats the wire and keeps the heat in the ejected base long enough for it to anneal. The rest of the lehr is the same as the cooling section of the heatless lehr.

Small Furnaces are Economical

The melting furnaces are small, continuous tanks (Fig. 6). They have been evolved over a long period and, while simple, are surprisingly economical. About the time the control was being perfected, the furnace was redesigned and the refractories in use entirely changed. The furnace of a few years ago measured inside 27″ wide x 77″ long x 15″ deep with a flat tile top. The oil burner was placed in the long side at the center. The flame was divided by means of an oil spreader so that one part heated the glass batch at the rear and the other part heated the glass over the top of the die. The present furnaces have practically the same dimensions, except they have a typical arch roof.

The efficiency of a furnace of this apparent crude design is surprising. Because the glass is black, only a 5″ metal (glass) level is carried. When delivering 2.2 lbs. per minute of glass (A), or 132 lbs. per hour (1.58 tons per 24 hours), 5.9 gallons of fuel oil at 30° Be (135,000 BTU per gallon) are used per hour. This figures out to be 89.5 gallons of oil used per ton of glass delivered, or 12,070,000 BTU per ton. When it is considered that a good modern large capacity furnace, with the best regenerators and construction, uses from 7 to 10,000,000 BTU per ton it is evident that the little furnace with no regenerator or recuperation is a very good producer. If 800 BTU is allowed per pound of batch or 1,600,000 BTU per ton for heating up and melting the batch then the furnace has an efficiency as a melting unit:

$$\frac{1{,}600}{12{,}070} \text{ or } 13.25 \text{ per cent}$$

Since the heat for fining is also included in this figure, an allowance of 15 per cent can be made for this item, making the net efficiency of the melting about 15 per cent. (In Glass Industry, June, 1935, Romig cites a 75 ton furnace of approved design with a melting efficiency of about 18 per cent.)

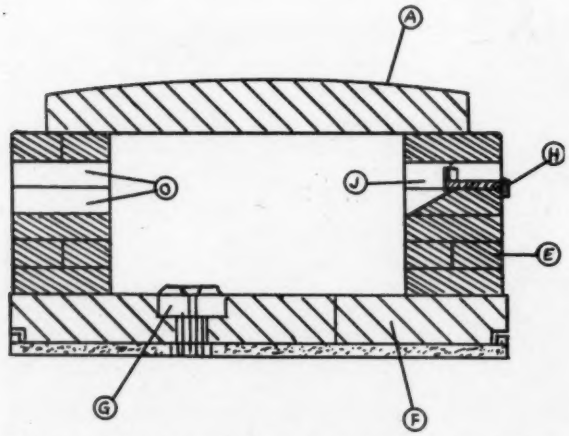


Fig. 7. Cross sectional view of old furnace. (a) common fire brick tile, (e) common fire brick, (f) common fire brick tile, (g) porcelain die, (h) iron frame support, (j) common fire brick post blocks, (o) common fire brick for charging hole.

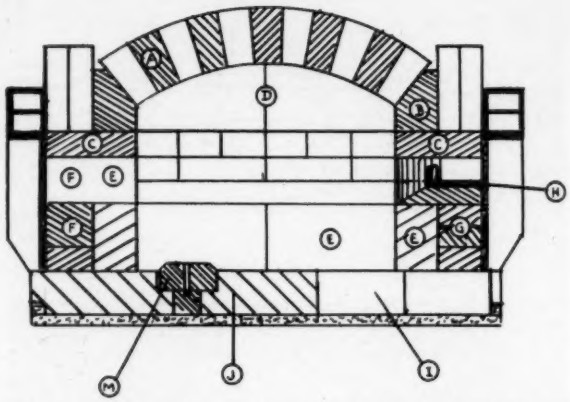


Fig. 8. Cross section of new furnace showing position of different types of refractories. (a) soft arch brick, (b) hard-burned alumina, (c) hard-burned sillimanite, (d) medium grade brick, (e) hard-burned sillimanite, (f) hard-burned alumina, (g) refractory insullating brick, (h) iron flame spreader, (i) medium grade brick, (j) common fire brick, (m) refractory die with alloy orifice.

The little base glass furnace delivers 132 lbs. of glass per hour for 14.63 sq. ft. of surface, or at the rate of 9.2 sq. ft. per ton per 24 hours. This is for both melting and fining. Ten sq. ft. per ton per 24 hours for melting alone, or 12.5 sq. ft. total melting and refining area is considered good practice for large furnaces, so here again the little furnace is a higher producer per unit area. The BTU per sq. ft. of melting and refining area is about 1,300,000 (for the little furnace) which compares favorably with 1,000,000 to 1,400,000 for large melting furnaces. The quality of glass delivered is fairly free from seeds and cords, although small lumps of refractories cause some trouble.

Refractories

Compared with a large tank the little tank has a very large line of contact between the glass and the refractory at the glass level line. In the furnace now in use this surface contact is 11 feet per ton capacity per 24 hours. In the article by Romig, a 75 ton furnace has only 2.3 feet contact per ton per 24 hours. It is thus evident that the glass level line refractory is a continual source of considerable trouble. The original furnace with the flat tile top (Fig. 7) was built of ordinary fire clay materials because they were considered cheap and easily renewed.

The new furnace has each different section made from a refractory suited to its particular use (Fig. 8). The furnace cost per hour of life is now only 25 per cent its former value. The new iron framework is much more substantial than formerly.

The experience in obtaining the bricks now in use had many interesting and peculiar angles. Only "cut and try" methods were possible. Early in the work it was found that the refractories had to meet severe conditions. The most important conditions were:

1. Must resist spalling on weekly shut-downs. The furnace is run 125 hours continuously then shut down over week-ends. During the shut-down period, if the

furnace is to be used the following week, a gas fire holds a temperature of 600° F. When re-started the furnace is brought back to 2500° F. in 6 hours. Sometimes a furnace must be shut down and held cold for a few weeks. It is started up in a hurry. This is rather hard on refractories but it is the most economical when all factors are considered.

2. Must not allow large pieces of refractory to enter into the glass stream and clog the orifice. Skimmerers are out of place and difficult to handle in the small furnace, so it is necessary to have on the glass level line, refractories of such a material that the least amount and smallest pieces will be dragged into the glass stream.

The Best Glass Line Refractories

One of the first materials tried was a high-grade sillimanite brick placed at the glass level. It was surprising to find that this lasted only a little longer than common brick. Consultation with several authorities on refractories was conflicting and a furnace was set-up with a collection of samples of bricks at the glass level line. This collection included brick made of sillimanite, mullite cast and pressed common and high-grade fire clay, chrome, magnesia, alumina, cast brick and glass tank blocks.

This test showed an ordinary Kentucky clay brick to be about equal to the best cast Mullite in life and erosion (Fig. 9). Further samples of the best lasting types were then placed in a new furnace and several runs made. The best all-around brick selected for the glass level is a fine grain sillimanite tile, hard burned. To minimize joints, these were made in tile form. However, to compromise between joints and breakage of long tile on cooling down, a piece of 18″ long by 7″ high x 4½″ thick is used. These are made up of very fine grain Sillimanite mixed with a small amount of clay and burned at 2500° F. Thus these tile shrink but little in service and the eroded material entering the stream is so small as not to clog the small orifices of the smallest dies. As a result these furnaces now last several times as long as formerly.

In the past, a newly built furnace could only be used for 300 hours on the small stream (1/32″) necessary for the miniature base before the lumps (refractory particles) in the stream made economical running impossible. A newly built furnace with the new refractories can be used for 3,000 hours on the same glass (B) before being discarded. A furnace is discarded due to the refractory interfering with the stream. A glass man would shed tears at the seeming waste of refractories, for the erosion is not more than 1″ when they are discarded. Thus the refractory cost of these furnaces is very high, being for the usual glass (A) about $0.80 per ton of glass delivered as against about $0.05 for a large furnace. There is room for research in this limited field for reducing the cost of this important item.

Insulating Brick

Since Sillimanite brick has a high heat conductivity, about 10 times that of common brick, it is necessary to insulate the outer side of these bricks. A refractory insulating brick is used for this purpose and accomplishes two things:

(a) Reduces the temperature gradient between the inside and outside of the Sillimanite tile, whereby thermal breakage on heating and cooling is reduced to a minimum.

(b) Reduces the heat loss due to high conductivity of the Sillimanite.

Besides the problem of the glass level refractory, the proper material for the arch top and the rest of the furnace, especially the openings, required considerable study. For the present, a common medium grade fire brick makes up the courses above the Sillimanite tile. The roof is of common soft arch brick except the arch

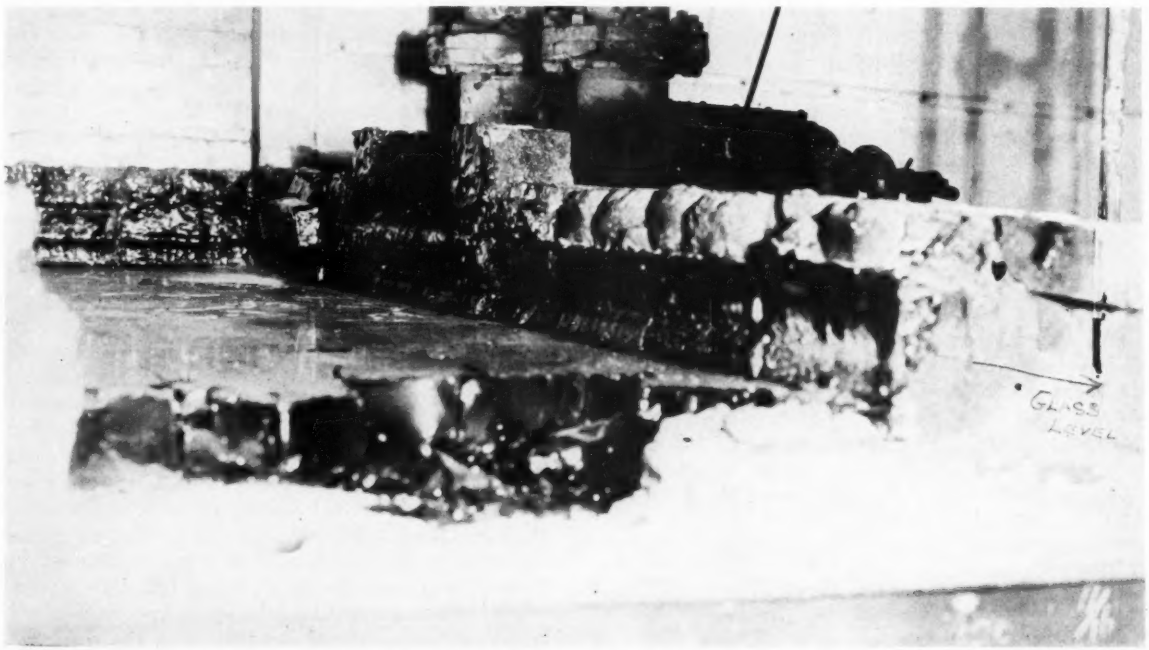


Fig. 9. One side of the experimental glass furnace, containing various refractories. Picture was taken after 8 weeks running. Glass level has been dropped before shutdown to show erosion.

support which is constructed of hard, burned-alumina brick.

Openings and Bottoms

One of the severest services for refractory is the charging opening at the rear through which the batch is placed into the furnace. The tops of these openings are made of the same material as the glass tile and last as long as the furnace. The exterior, sides and bottom are of hard burned alumina (75 per cent Al_2O_3), the inner sides are fine grain Sillimanite. The front opening is entirely of alumina. The special brick around the burners are also of hard burned alumina, except the plate over the top which is of the sillimanite glass level tile material. Bungs are preferably of the Alumina type material.

Bottoms are of partially used brick if properly anchored, or common fire clay tile. The front bottom tile is made special with a hole to take the orifice.

The present furnaces are well constructed with a strong angle iron framework upon an iron table with a 1″ top. The bottom of the furnace is 36″ from the floor. The present refractories are very well balanced as all come to the end of their usefulness at about the same time.

It is still desired to lengthen the life of the refractories but the present good life so minimizes the possible economy that there is little justification for much experiment work unless large results are indicated for small outlay of time and experimental money.

* Detailed in a paper presented to the American Ceramic Society, Cincinnati, Ohio, Feb. 1934. See J. A. C. S. Aug. 1934; and "Alloy Orifices in Refractory Dies", Glass Industry, June, 1935. The technological changes and labor used in this process are noted in Bull. No. 593, U. S. Bureau of Labor Statistics, Page 23-25.

A NEW GLASS

The Thermolux Glass Company, a subsidiary of the Triplex-Safety Glass Co., Ltd., is making a new type of glass which influences both the temperature and lighting of buildings so glazed.

The new product consists of two panes of ordinary clear glass with a middle layer of glass silk, through which the rays of the sun do not pass, as through ordinary clear glass. The special properties of the product, it is claimed, result in an almost entire absence of shadow. —From *Food Manufacture.*

C. L. BABCOCK JOINS O-I STAFF

C. L. Babcock, Instructor in the Glass Technology Course, Purdue Physics Department, has joined the research staff of the Owens-Illinois Glass Co.

Mr. Babcock was formerly Corning Glass Research Fellow at Purdue University, and has been collaborating with Dr. K. Lark-Horovitz in the investigation of electrical conductivity and viscosity of glasses. He will assume his new duties at Alton, Illinois, on July 1st.

Mr. J. E. Ferguson, formerly Turner Glass Research Fellow at Purdue University, will succeed Mr. Babcock in the Glass Technology Course at Purdue.

Dr. Henry Phelps Gage, chief of the optical laboratory at the Corning Glass Works, is reported to have lost the vision of his right eye on the fourth of July. The trail of fire from a sky rocket says the report set off an abandoned fire cracker, which exploded.

THE CHEMICAL ENGINEER IN THE GLASS INDUSTRY

Professor Alfred H. White, head of the department of chemical engineering at the University of Michigan, has written to The Glass Industry calling attention to the special facilities available there and the opportunities for special study in chemical engineering. The glass industry, he states, is one which has profited much and may profit more through the application of this science to its problems.

While the chemical engineer's work must be based on a thorough knowledge of chemistry, he is far from being a laboratory chemist. He must have considerable attainments in the important fields of physics and mathematics, as well as in metallurgical engineering, and must apply these in almost the same degree that he does chemistry. This obviously indicates the need of more than four year's study. And its importance is definitely recognized by many of the larger corporations, who prefer a man with a master's degree to one with a bachelor's degree, on the grounds that the man with post graduate training advances further than the equally able man without it. They recognize this not only by being willing to employ men with advanced degrees, but by paying higher salaries.

The University of Michigan has one of the oldest and largest courses in chemical engineering in the United States, and one that includes a number of courses which make graduates valuable in the glass industry. All of the students take courses in engineering materials, fuels and furnaces, chemical technology of the inorganic industries and unit operations. They also have opportunity for limited specialization in their senior year in some chosen industry. They may take special courses in furnace design and construction and in pyrometry and furnace control and in applied thermodynamics.

The Department has assigned to it over one-third of the 160,000 square feet of space, with 80 rooms—including laboratories, classrooms, offices, etc. It is also fortunate in its neighbors—the forge shop and foundry of the Department of Metal Processing are adjacent to and cooperate closely with the metallurgical laboratories; the highway laboratories with their facilities for study of the properties of cement, brick, and asphalt are also in this building; the Department of Engineering Research with its many-sided activities has its headquarters here.

The Ceramics Laboratories consist of a kiln room, preparation room, and laboratory. The kiln room is equipped with oil- and gas-fifired recuperative kilns for high-temperature work, and for testing and burning properties of clays and refractory products. The preparation room includes crushing and grinding equipment, a dry pan for fine grinding of shales and hard clays, two mixers, a pugmill and extruding machine, glass-topped tables, and other equipment used in preparing clays for burning. The laboratory is supplied with a Fairbanks testing machine, volumeter, and means for analyzing and testing the raw and burned clay and foundry sands.

These facilities at the University of Michigan are described in an illustrated bulletin which may be obtained free on application to the Department of Chemical and Metallurgical Engineering, 2028 East Engineering Building, Ann Arbor, Michigan.

FLOW OF GLASS IN FOURCAULT TANKS

By J. GAVIN CALLINAN

OPERATION of small single-unit continuous tanks often affords excellent opportunities to study the glass-melting process; because the small tanks are flexible, distances are short, and observations easier and more convenient to make. Experiments as to firing, temperature, design, and batch can be undertaken without the fear of results that on a large tank would be dangerous and costly.

Among other studies, the flow of the glass in a small Fourcault sheet machine tank was determined. This tank was three feet deep throughout, eight feet wide in the melting end and seven feet six inches wide in the drawing end. Two solid floaters, A and B in Figure No. 1 were underneath solid jack-arch walls that effectively separated the two divisions of the tank, and C, the third floater (here known as an underbridge) was immediately in front of the machine. All three of these pieces were submerged about seven inches in the glass.

The melt was made with three ports on each side, regenerative system and the glass temperature in the melting end was kept at 2600 degrees F. The temperature fall after the first floater A was quite rapid and generally doors in the breast walls between A and B and B and C were kept open in order to help cool the glass to a temperature suitable for the drawing operation. Occasionally a water-cooled pipe was inserted at varying distances above the glass between B and C and only when it was within an inch of the glass surface did it seem to have any effect on the flow.

The following is part of the notes taken on this tank: Small floats and stones were timed in their travel down the tank. The speed of travel on the surface between floaters A and B was approximately 3.7 inches per minute and between B and C about 5.4 inches per minute, this last measured over an 8 ft. 6 in. course.

The floats in all cases went straight down the tank with no apparent tendency to curve towards the sides and the flow close to the sides was practically as fast as that in the center. Stones that had been submerged by floater A would come up on the machine side of the floater and within an inch of it. Again, when they approached either floater B or C they would get very close, seem to hesitate a few seconds, then go down and come up on the other side, again very close to the floater.

The time required for the glass to pass from in front of underbridge or floater C to the point of sheet formation may be approximately from the following observation:—

During one period of the operation there was a line in the sheet whose source was determined to be either at floater A or at floater B. A broad hook was pulled across the tank in front of underbridge C at a depth of about 14 inches. Fifty-eight minutes later a distinct change was noted in the sheet at the top of the machine. This machine was drawing heavy glass at the rate of ten inches per minute and required twenty-seven minutes to pull from the lips of the debiteuse block (drawing block), which would be the point of sheet formation, to the point of observation at the top of the machine. This left just thirty-one minutes for the glass to pass from in front of the underbridge to the lips of the debiteuse.

The depth of the flow is a matter of conjecture. With the machine pulling 13,128 pounds of molten glass in twenty-four hours and if there were no return flow, the depth of flow in zone A to B would be ¼ inch, and in zone B to C it would be ⅜ inch. In the same manner a depth or thickness of flow can be calculated for the last passage to the sheet and found to be 1⅝ inches.

Actually, deeper flows in the zones A to B and B to C exist. Assuming a flow two inches deep and seventy-seven inches wide (as was indicated by the observations), the weight of glass moving forward in the zone B to C would be 54,054 pounds in twenty-four hours, or 30,926 pounds in excess of that being drawn out by the

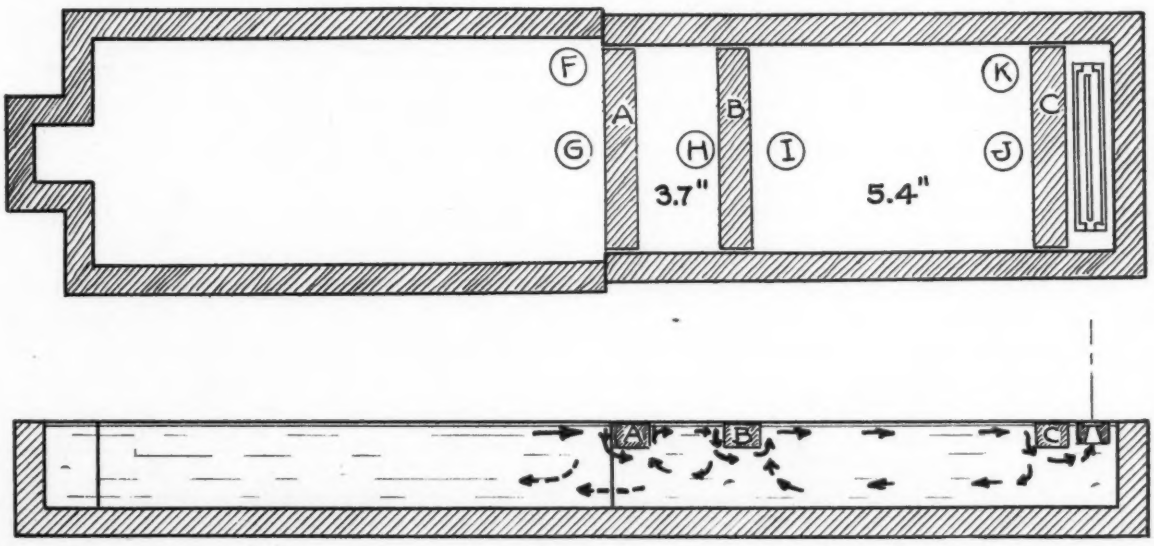


Fig. 1.

machine. In other words, on the above assumptions only 24.3 per cent of the flow is being extracted to make the sheet.

Temperature conditions of the tank averaged as shown in Table No. I.

Table No. I

Location	Degrees F.*
G	2490-2500
H	2330-2350
I	2200
J	2030-2050
K	5 to 30 deg. less than J

* Temperatures on the surface of the glass measured by means of an optical pyrometer.

Temperatures taken at F. with an alumel-chromel thermocouple in a closed end alloy tube gave:

Top. 2485 deg. F.
18" down. 2400
Bottom. 2070

Flow conditions in large tanks are much more complicated as other observers have shown. Koenig* has given us results of many close observations on large Fourcault sheet machine tanks. One sketch showing flows in the drawing canal checks closely with some observations made on an 821-ton sheet glass tank whose daily output was 62 tons. The tank was drained at the end of the run and when cool the side wall blocks were carefully examined.

Figure No. 2 shows a plan view of the tank and the other figures are elevations of the side walls as marked. X indicates the location of the drawing machines and H indicates the intermediate heating chambers where heat was applied.

Lines cut into the blocks by the glass are shown exactly as sketched in the tank. If these indicate the path of the glass currents, they confirm the schematic drawing by Koenig. They show the currents set up by the heat applied in the chambers marked H and the contamination of the glass supply for the second and the third drawing machines by glass that has swept close to the relatively cold bottom of the drawing canal.

Figures 5 and 6 are elevations of the neck, as marked, and show badly worn places at the corners where the refining end meets the neck. Block joints complicated matters at these points; but from all indications these places probably marked the location of the forward and return flows.

S shows the location of a solid bridge-arch that sealed

*Glasstechnische Berichte, and Ceramic Industry, Dec. 1929.

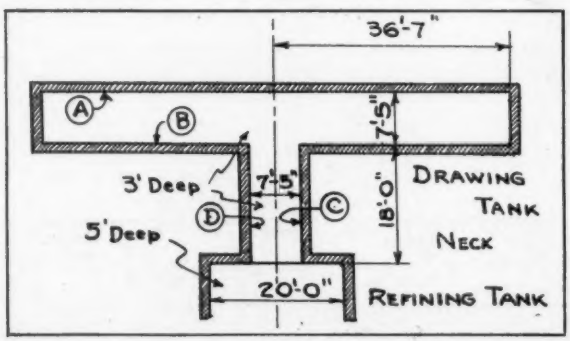


Fig. 2.

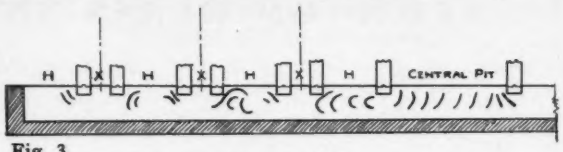


Fig. 3.

WALL A

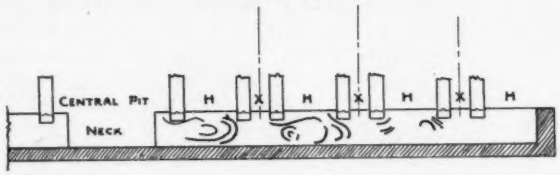


Fig. 4. WALL B

off the neck above the glass and was immersed into the glass for about eight inches. The lines on the blocks on the machine side of this bridge-arch do not seem to indicate a return flow but rather a more or less circular flow around axes Y-Y and X-X.

In all sheet machine tanks of tee-design and also in any tank where considerable heat is applied to the glass in the working end, the currents are very complicated and as has been pointed out by others, are, frequently responsible for poor glass quality, especially in the case of the second and following machines in a Fourcault sheet glass tank of the above design.

In one instance, a Fourcault heating chamber was being supplied with a relatively hot glass and at the same time a fire was being used in the chamber. A temperature investigation disclosed the fact that the "fire" was really cooling the glass; as there was a tremendous excess of air being supplied from the regenerators, which at that time were being operated at a dull red heat. Aside from the waste of fuel the localized cooling probably set up counter-currents that from time to time as changes took place, adversely affected the machine operation. Proper combustion equipment would eliminate such unsuspected changes, which directly influence the quality of production.

Such combustion equipment tied in with control apparatus could be arranged to anticipate changes in the body heat of the tank glass or in the heat being brought to a drawing chamber by the glass and adjust the fires in ample time so that the optimum operating conditions would be maintained. Visual control, which does not detect trouble until it is indicated by the quality of the glass, is economically out of date. (*Concluded on p.* 248).

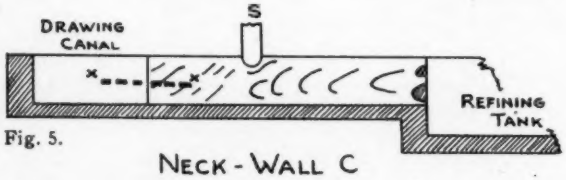


Fig. 5.

NECK - WALL C

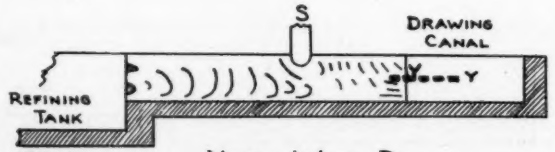


Fig. 6. NECK - WALL D

THE GLASS CONTAINER INDUSTRY

The Second Article of an Unusual Series in which the Economic Problems of the Industry Are Competently Analyzed

By W. STANLEY RENDALL

IN CONTINUING discussion of the Economic Problem and the so-called "measuring stick" against which it is planned to evaluate the various factors which enter the problem, it is desirable to emphasize that a glass container is a secondary commodity until filled and retailed to the ultimate user of the contents.

This means that the economic problem of the industry is an integral part of the larger and more complex problem of satisfying the demand for containers of all types for the merchandising of consumable products, and from this standpoint the glass container industry is only one of several industries operating at least part of the time in competition, one against another.

Each of these competing industries took recognition of the provisions of the National Industrial Recovery Act to create a code, the character of which was to establish a measure of planned economy as a basis for safeguarding the economic interests of capital and labor; not however as applied to the container industry as a whole, (excepting for those mandatory provisions intended primarily as an economic guide) but related solely to the specific industry concerned. In other words, the competitive factor, as between glass, metal, paper, synthetic resins, and other materials usuable for containers, remained unaltered.

It is obviously of fundamental importance to recognize that, while the economic problem within the glass container industry may, over a period of time, be solved, such a result, however desirable from a detached standpoint, may prove to be an empty victory, and that the several elements of control, such as patents, licensing, restrictive measures—both legislated and voluntary—will result in retarding free competition and enterprise to the disadvantage of both capital and labor, as this is now employed in the glass container industry.

It would be distinctly bad economics for the industry to agree to any policy tending towards what might be termed "over control"; particularly if during the working out of such a policy, individual enterprise in the industry intent upon bringing about the best possible service to the ultimate users of containers is forced to limit this enterprise to the rules and regulations of control.

Those concerns and organizzations which have acquired the privilege of formulating industry policy should properly contribute a form of leadership, based upon sound economic teaching and with due regard to the profit and loss position of the individual concerns which comprise the industry.

The basis of economic teaching should be the serviceability of glass containers to the ultimate user, as compared with other types of containers.

THE ECONOMIC PROBLEM

"Analysis of the economic problem, in order to be practical and useful as a basis for formulating conclusions, must necessarily be based on reliable facts concerning all phases of the problem.

"Unfortunately, and in spite of the opportunity afforded by the Code for the collection and assimilation of facts, these have largely been restricted to quantities of production, shipments, and stocks of finished ware.

"Nowhere in the industry has a 'measuring stick' been perfected to include the comparative performance of equipment and the character and incidence of production, the suitability and quality of the industry's production in relation to competing products, the characteristics of market, or finally a comparative basis of costs and earnings. The industry as a whole is without a concerted labor policy as related to welfare and social security.

"It is, of course, hardly conceivable that any real or lasting stability can be achieved so long as individual concerns in the industry are without any form of comprehensive 'measuring stick' of the factors above mentioned, and the purpose of this series of articles is to present to the industry an outline of the economic problem and to analyze such facts as are available." —W. Stanley Rendall in the July GLASS INDUSTRY.

THE BUSINESS PROBLEM

Whatever the character of an economic problem may be, its solution requires the organization and machinery of research, engineering, and scientific development, finance and merchandising. This can be called the Business Problem, and is concerned with stability and permanency of enterprise as related to reasonable earnings and security of investment.

More enlightened business readily admits the responsibility of maintaining the highest possible standard of living for labor and its maximum employment. This does not mean that regimentation of industry as a political or legislative step is essential to the attainment of the business objective, but simply that each individual concern in the industry and each complementing service should recognize the interdependence of each service to a common objective.

The common objective in the glass container industry is to create and maintain the largest possible market for its product, which latter, in order to become a primary commodity, has to be capped or sealed, the contents identified by a label or some similar marking, and packed in some suitable container for transportation.

In successfully accomplishing this objective; which, within the scope of both the economic and business problems, must result in reasonable earnings and stability for both capital and labor, the following factors can be considered fundamental:

1. Price in relation to competing products.
2. Serviceability in relation to competing products.
3. Flexibility and range of production equipment to meet the incidence of orders and shipments.
4. Costs of manufacture and distribution.

PRICE

A major part of the total production of glass containers is marketed without competition from other products. Competi-

tion is primarily within the industry. The absence of intense external competition can be attributed to at least three causes:

1. The inherent cheapness of glass and its automatic fabrication into containers.

2. The relatively high standard of quality in respect to appearance, freedom of contaminating influence on contents, accuracy of capacity, and reliability of finish for closing—capping or sealing.

3. The almost unlimited range of types and sizes available to buyers.

Considering the essential services performed by a glass container, complete with cap or seal, as a convenient and hygienic means for distributing various products, in aiding sales and the ultimate convenience in domestic use, the cost of such service is notably cheap and suggests the reasonableness of expecting to find considerable stability in the glass container price structure and the profit and loss position of individual concerns engaged in the industry.

Was the 1933 Code a declaration by the industry that it lacked reasonable stability of price structure and earnings, and further, are the discussions now proceeding in the industry relative to a reformulation of the 1933 Code, basically concerned with this same problem?

From such published statements and statistics as are available, price structure has resolved itself into being an inevitable result of large scale organization, showing a sufficiently attractive differential between costs and selling price, to satisfy capital, to meet obsolescence, to indulge in new economic enterprise, and to pursue an enlightened policy towards labor.

Mention has already been made of the distribution of productive capacity whereby "approximately 10 per cent of total concerns control about 70 per cent of total capacity." This group can be considered large scale, and the balance of 90 per cent of total concerns controlling 30 per cent of total capacity can be considered small and medium scale organizations. Keeping in mind that the total capacity of large scale organization is 65 per cent in excess of consumption, it is quite obvious that the industry is confronted with a situation requiring at least some measure of control to avoid excessive competition, and the consequent demoralizing effects on price structure.

How can this be accomplished without curtailing individual enterprise? Experience has shown that a quota system in practice inflicts either a burden on large or small scale organization, and finally leads to evasion, compromise, and to the same mechanisms of business or commercial policy as have been used since the simple law of supply and demand became the recognized and unalterable fundamental of our economic existence. Four such mechanisms can be cited:

1. Continuation of excessive competition to the point of financial exhaustion of the weaker concerns.
2. Organized price agreements.
3. Merging of groups of concerns to restrict productive capacity.
4. Production control by licenses or patented processes.

The first method always exists to a greater or lesser degree, and is subject to many factors such as plant location to market, management, etc.—all of which factors are subject to change.

The second method is not only unlawful but usually lacks permanency.

The third method is the most common and practical, particularly if coupled with—

The fourth method providing the development to be licensed is proved to be novel, original, and is supported by highly organized service work, both engineering and economic.

SENATOR ASKS PROBE OF GLASS CONTAINER TRADE

The glass container industry is dominated by large corporations which have pooled patents, according to Senator Duncan U. Fletcher, of Florida, who has asked the Committee on Interstate Commerce to ferret out the malefactors.

His inquiry would cover specifically the manufacture and sale of milk bottles, beverage bottles and pharmaceutical ware.

Corporations holding thousands of patents dominate the industry, the Senator charges, to the continuing disadvantage of other manufacturers, small enterprises and the consuming public. This, he considers, affects the national defense, since the armed forces cannot operate effectively while patent pools control articles necessary to the army and navy.

REFRACTORIES DIVISION MEETS

The Refractories Division of The American Ceramic Society will hold its summer meeting on September 20 and 21 at Penn-State College, State College, Pa. Guests will assemble at 12:30 A. M. Friday for luncheon at the Center Hills Country Club, located two miles southeast of State College. Following lunch, a technical session will be held at which the subject for discussion will be "Trends in the Use of Refractories."

Entertainment features are provided for both Friday and Saturday. Friday evening at 8 o'clock there will be an "Outing of the Pittsburgh Clay Workers Club" at the Bear Meadows Clay Pits. While the Outing is in full swing, the ladies will hold an entertainment elsewhere, details of which are to be announced later. On Saturday, ceramists will have the option of golf, swimming or tennis at the Country Club, or they may take excursions to any one of a number of near-by points of interest, such as Fisherman's Paradise, Penn's Cave Greenwood Furnace or Shingletown Gap.

JUNE PLATE GLASS PRODUCTION

The production of polished plate glass by member companies of the Plate Glass Manufacturers Association in June totaled 13,162,515 square feet as compared to 14,581,557 square feet in May. This makes a total of 88,363,275 square feet produced during the first six months of 1935.

Work has just been begun on a new $235,000 addition to the plant of the Obear-Nester Glass Co. at East St. Louis, Ill.

THE ADHERENCE OF GLASS TO METALS

By NELSON W. TAYLOR*

THE present trend in theories of adherence of different materials in contact is toward an expression in terms of chemical forces. The choice of proper collecting agents for the flotation of minerals is largely made in the effort to bring about reactions on the mineral surfaces, as for example, a film of lead xanthate on a galena surface to give it hydrophobic properties. The problem of paint adherence is being studied intensively from a chemical viewpoint. The nature of lubrication is being studied from this angle. Strong seals of rubber to metal have been made by taking into account the electrical properties of the latex colloid. Many other examples might be cited.

With this in mind it is not surprising that the question of glass-metal seals should be examined in terms of possible chemical reactions. It is well-known that platinum or gold seals in glass are difficult to make as compared with oxidizable metals like tungsten and copper. In view of the chemical inertness of platinum and gold these observations point to a chemical rather than to a mechanical theory of adherence.

Requirements for a good seal. For success in making strong glass-metal seals there are at least two requisites. The first of these is the question of getting good contact, most effectively by chemical reaction, so that the strength of the seal is that of a real chemical bond. The second has to do with the prevention of thermal strains, such as arise from different expansion coefficients. Great progress has been made on this point, and a recent paper by Hull and Burger[1] provides expansion data on several new alloys which almost exactly match certain standard commercial glasses. Some workers recommend a slightly higher coefficient of expansion for the metal, since this results in keeping the glass in compression which is its strongest condition, as illustrated by the great strength of quickly chilled sheet glass. It should be borne in mind however, that a match or a near match in expansion is of no particular value unless the glass and metal are really in contact, and held so by molecular forces. The present article deals with this aspect of the problem.

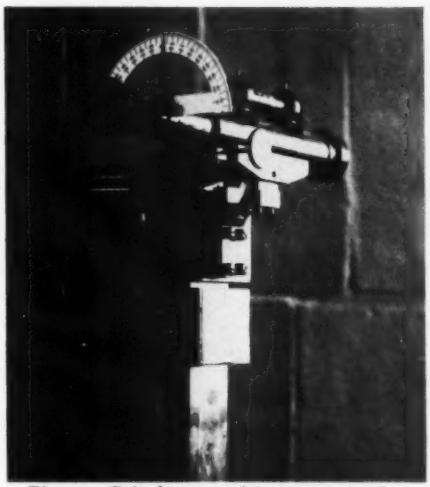


Fig. 1. Calorimeter with protractor for contact angle measurements.

Application. It is hardly necessary to point out to a glass technologist the practical importance of a better understanding of the nature of glass-metal adherence. Ever since the first electric light bulb was made, and to an increasing degree with the myriad of vacuum tubes which have developed, the problem of suitable wires for sealing into glass has demanded attention. In the wire-glass industry the practice of imbedding wire mesh into sheet glass, has not always resulted in an increased strength for the whole structure. Usually there is a good deal of entrapped air, and the contact of glass and wire is very poor. Proper attention to the oxidation characteristics of the wire ought to lead to considerable improvement in wire-glass. Spark plugs require tight seals of metal wires in glass. Another field of application is in glass tops for tin cans, which is a recent development. Decoration of glass table ware by metal has many artistic and practical possibilities. Perhaps the most extensive present day application is in the vitreous enamelling of cast iron or sheet steel. Progress in this field has been very rapid in the last few years, due to the general recognition of the corrosion resistant and decorative possibilities of glass applied to metal surfaces. Both the enamelists and the metallurgists have energetically attacked the many problems in this field, with more uniform and better products from each group.

The negative aspect of adherence, i.e., prevention of adherence, is a problem of equal importance in machine handling of molten glass, mechanical molding, etc. Clean non-oxidizing metal surfaces are required.

The experiments which are to be described have been made in the ceramic laboratories of the Pennsylvania State College, largely as the result of a desire to throw more light on the nature of enamel adherence to sheet iron. The writer does not claim originality for all of the ideas presented. The literature abounds with references to the reaction theory of adherence and a recent paper by Staley[2] presents convincing evidence along these lines. However, certain novel methods of experimentation have been used in the present work, which may be of general interest and applicability. Before presenting the details of these experiments it may be worth while to outline the theory on which they were based. For this a little elementary thermodynamics will be inflicted on the reader.

Some Elementary Thermodynamics. Suppose that a bar of glass of 1 cm² cross section is torn apart by a force F_g to create two new surfaces each of 1 cm². The work done is equal to $2\gamma_g$ where γ_g is the surface tension. It is also equal to $F_g \times d$ where F_g is the necessary force and d is the distance over which the force must operate against molecular attraction. Therefore $F_g\, d = 2\gamma_g$. The same argument applies to a bar of metal, and we may write $F_m\, d = 2\gamma_g$.

If now we tear apart a glass-to-metal seal of 1 cm² cross-section, the work done is $F_s\, d = \gamma_g + \gamma_m - \gamma_s$ where the symbols represent the same quantities as be-

*Head, Department of Ceramics, The Pennsylvania State College. With the technical assistance of D. I. Dilworth, T. M. Fairchild, L. P. Lias and D. H. Wertz, senior students in Ceramics and Metallurgy.

fore and the new symbol γ_s represents the interfacial tension of the seal, i.e., the work necessary to create 1 cm^2 of interface. It is clear from the equation that the necessary force F will increase as γ_s is decreased. In making a good seal the objective is therefore to get γ_s as small as possible.

The Need for a Transitional Zone. Let us now consider the nature of the interface from a molecular viewpoint. A high interfacial tension means that there is a marked molecular discontinuity between the two phases in contact. On the one side is the metal with its loosely bound electrons and consequently opacity and high electric and thermal conductivity, on the other side is the glass with ionic properties much like an aqueous solution, and its consequent optical transparency and low electric and thermal conductivity. The discontinuity at the phase boundary in the nature and magnitude of the forces, and in the molecular structure is even more marked than in the system oil-water which form two mutually immiscible liquids. Normally the discontinuity is so marked that metal and glass readily separate, as they do in the steel blast furnace or in the open hearth. It is possible, nevertheless, to reduce the discontinuity to a great degree by the introduction of a transitional zone between the two adjacent phases. In the case of an oil-water interface this is accomplished by use of a substance like soap (sodium oleate) which shares the properties of both liquids, and which, as shown by Gibbs, Langmuir, Adams and others, concentrates at the interface and orients its molecules in such a way that the sodium end dissolves in the water and the oleate in the oil. One might say that the sodium oleate is a double ended chemical hook, with one end grappling the water molecules and the other end grappling the oil molecules, thereby firmly holding them together.

OXIDE-FILM THEORY OF ADHERENCE.

Going back now to the glass-metal system, it should be clear that what is needed for the transitional zone is a substance having to some extent the properties of both glass and metal. A number of heavy metal oxides and possibly some sulfides possess these characteristics. On the one hand, many of the metals adsorb oxygen vigorously to form adherent non-permeable oxide films which give protection against further oxidation of the metal. Such an oxide is Cu_2O. On the other hand, most oxides are soluble in glass to a greater or less degree and thereby bond to the glass while at the same time they

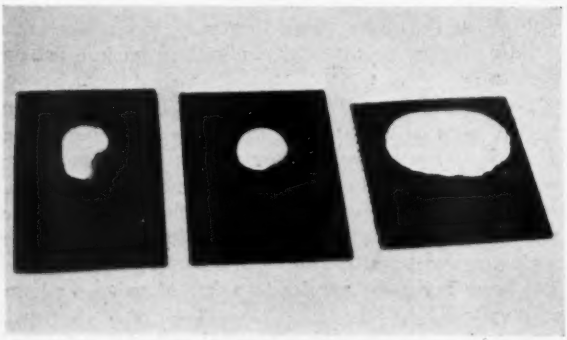


Fig. 2. Enamel billet in three stages of spreading on sheet iron.

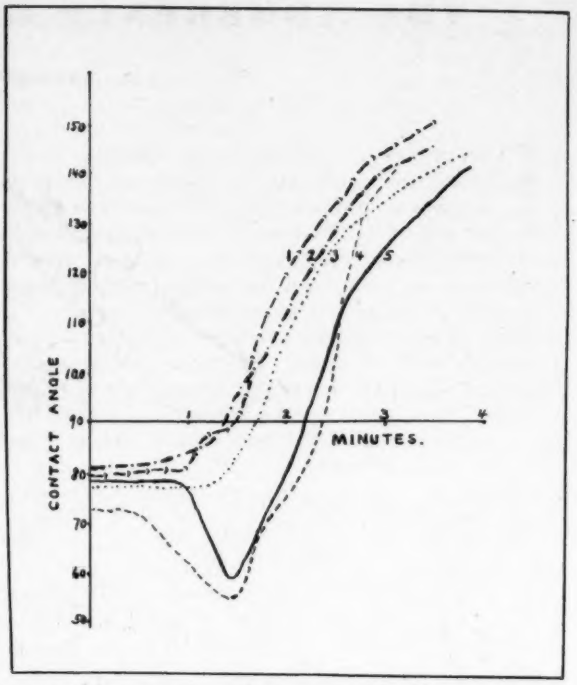


Fig. 3. (1) Sb_2O_5 (2) Fe_2O_3 (3) CoO (4) CR_2O_3 (5) plain enamel.

modify its properties in the direction of those of the oxide. Certain oxides like SnO_2 or ZrO_2 have rather low solubility in enamel glass and are used as opacifiers. Oxides like MgO or CaO are rather soluble. The heavy metal oxides of iron, cobalt and nickel fall into an intermediate position. The solubility does not have to be large, however, to give the necessary bonding. As mentioned earlier oxidizable metals like tungsten or copper can readily be sealed into glass. It is also a well-known fact that sheet iron must be enamelled in an oxidizing atmosphere. Three methods for oxidizing such a metal surface may be listed:

1. Oxidation by a gas phase, such as air or steam.
2. Oxidation by material applied as a coating to the metal.
3. Oxidation by something dissolved in the glass.

In forming the ground coat on sheet steel enamels, methods 1 and 3 are generally used in combination, although one company is getting very good results by a combination of 1 and 2. In sealing wire into glass, method 1 is generally used alone, although there is no obvious reason why method 2 or 3 could not be used.

EXPERIMENTAL.

The experiments outlined herewith had to do mainly with testing method 3 in regard to enamel-sheet steel contacts. A series of oxides likely to oxidize iron at enamelling temperatures (855°C) were chosen and these were incorporated by melting into the neutral enamel frit.

Contact angle measurements. In one group of experiments the neutral or "plain" enamel (containing no adherence-promoting oxides) was mixed with sufficient clay, $MgCO_3$ and water to give good floating properties. This mixture was ball-milled, evaporated to dryness and pulverized intimately with two per cent by weight of one of the following oxides: Sb_2O_5, Sb_2O_3, Fe_2O_3, CoO, NiO,

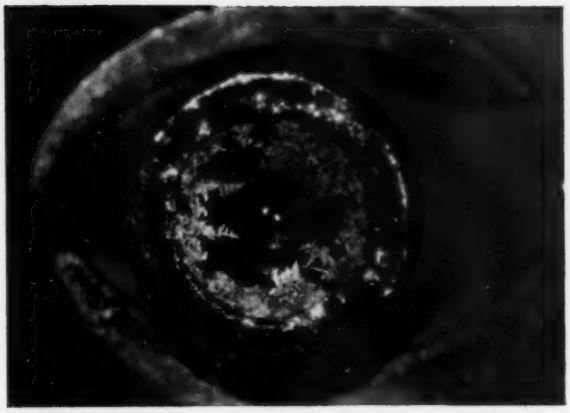


Fig. 4. 5% NiO in commercial enamel. Three hours heating in iron cup at 850°C.

MnO_2 and Cr_2O_3. Each mixture was then placed in a carbon mold and heated in a small gas-fired pot furnace to a high enough temperature to cause melting. The carbon mold was then removed from the furnace and the pellet allowed to cool while still in the mold. The latter was then ground away by an abrasive wheel, leaving a clean pellet 3/8" high and 1/4" in diameter. The pellet was then placed on a piece of sheet iron and preheated for 3 minutes at the open end of a horizontal muffle tube furnace. At the end of 3 minutes it was pushed 2 inches into the muffle and allowed to rest there for 2 minutes. Then it was pushed all the way in to the hot zone. Since all the pellets were inserted the same distance into the muffle and were given the same 5 minutes preheating, there was little chance for error in heat treatment. By means of a horizontal telescope having rotatable cross-hairs the angle of contact between enamel and metal could be observed. This was measured by a pointer-protracter combination mounted on the telescope* as shown in Fig. 1. As the enamel wet the metal surface and spread over it the contact angle progressively changed as shown in Fig. 2. Readings were taken at intervals of 15 seconds. These data were recorded and plotted against the time. Results are depicted in Fig. 3.

As will be seen in the figure the contact angle normally starts at some value less than 90°, usually about 80°. This is because of the chipping of the corners incident to grinding the pellet. As the pellet begins to soften its own surface tension rounds it somewhat at the base, so that the contact angle becomes more acute. The angle may drop to as low as 55° or 60°C. Later, when true wetting of the metal by the enamel occurs, the base rapidly spreads, the contact angle passes through 90° and goes on to higher values (140° to 170°).

The 90° line was selected as a basis of reference and the pellets with these additions of various oxides were contrasted according to the time required to cross the 90° line. An enamel with good wetting qualities for the metal would spread rapidly and pass the reference line more quickly than one of poor wetting qualities.

The shape of the curves beyond 120° was not considered of particular importance in regard to the rate of wetting although possibly the equilibrium value of the contact angle after several minutes may give useful information as to the exact ratio of surface tension and interfacial tension. Since the usual enamelling operation requires only two or three minutes, it was felt that the earlier part of the curves were of principal significance.

The "plain enamel" curve at first veered sharply to the small angle of 60°. Approximately 2.25 minutes elapsed before the angle had risen to the 90° position. The "plain enamel" carried no oxidizing agent. On the other hand, the Sb_2O_5 enamel showed no minimum contact angle whatsoever but began to spread immediately. The Sb_2O_5 enamel showed a 90° angle after only 1.4 minutes. The CoO enamel required about 1.7 minutes. As is well-known both of these oxides are capable of oxidizing iron, the former changing to Sb_2O_3 and the latter to metallic cobalt. It seems evident that easy wetting and rapid spreading is bound up with the oxidizing action of these enamels on the iron. The enamel containing two per cent Fe_2O_3 showed excellent wetting characteristics. Its behavior was much like that of Sb_2O_5. The enamel began to spread from the first and reached 90° in 1.5 minutes. This is perhaps not surprising in view of the well known reaction $Fe_2O_3 + Fe \rightarrow 3FeO$.

The poorest spreading behavior was shown by the enamel carrying two per cent Cr_2O_3. The contact angle dropped to the low reading of 55° and about 2.4 minutes were required to bring it back to 90°. In view of the well known difficulty in reducing Cr_2O_3 to the metal it will be seen that a reaction between $Cr_2O_3 + Fe$ is improbable. This observation thus bears out the theory that oxidation of the iron is a necessary part of the wetting process. The oxides CoO, NiO, MnO, and Sb_2O_3 occupy an intermediate position. Only CoO is shown.

In another series of experiments chemically equivalent weight of oxides were taken, as shown in the following list: 2.0 per cent Sb_2O_5; 1.8 per cent Sb_2O_3; 1.06 per cent BaO_2; 1.0 per cent Fe_2O_3; 0.54 per cent MnO_2; 0.47 per cent NiO. The times required for the contact angle to reach 90° were as follows: Sb_2O_5 1.35 minutes; Fe_2O_3 1.45 minutes; MnO_2 1.9 minutes; NiO 2.05 minutes; Sb_2O_3 2.2 minutes; BaO_2 2.35 minutes. In this case the enamel containing Sb_2O_5 was the only one which began to spread from the first. The other enamels all showed preliminary tendency to gather into spheres before spreading began. The relative position of Sb_2O_5 and Sb_2O_3 are noteworthy, again in harmony with the oxidation characteristics of these oxides. MnO_2 and NiO are also better than Sb_2O_3, as one might anticipate in view of their use in ground coat enamels. The behavior of BaO_2 is interesting. As a peroxide it ought to be a very good oxidizing agent. Actually it is too good.

Fig. 5. 4% Co_3O_4 with sodium borosilicate glass. Four hours heating in iron cup at 850°C. x 150.

It is unstable and loses oxygen above 600°C so that all that was present was the comparatively inert BaO, which is certainly not reducible by iron.

A series of runs made with concentrations of Sb_2O_5 from ½ to 16 per cent showed that the best range for rapid spreading lay between 2 and 4 per cent. At higher concentrations viscosity reduces the spreading rate.

Summarizing these observations, one may say that oxidation of the metal is an essential requirement for wetting the metal surface by the glass phase. The experimental proof would of course have been better had data been obtained on the viscosities of the various melts, but in view of the small concentration of the different oxides it is not likely that marked viscosity changes occur. And the technique for measuring contact angles is simple and precise and deserves wide application.

CHEMICAL AND METALLOGRAPHICAL TESTS

The other phase of the adherence problem investigated in this laboratory has consisted in a chemical and photomicrographical study of the enamel-metal contact. Samples of prepared enamel frit were melted in small cups which had been drilled out of "ARMCO Ingot" iron rod. They were placed in an electric furnace and held at 850°C for lengths of time varying from 30 minutes to eight hours. Observations were made on a commercial enamel (A) with various oxide additions and also on a sodium borosilicate glass with various oxide additions. The glass had the ratio $Na_2O: B_2O_3:SiO_2 = 1:3:8$ composition (by weight) which has an expansion coefficient ($11x10^{-6}$) slightly less than that of the metal ($12x10^{-6}$). The durations of firing are of course very long compared with commercial practice, but it was desired to bring out the chemical changes as distinctly as possible. After firing the surface was ground and polished for examination.

The samples, after firing, showed some very interesting effects. Enamel A (containing no adhering oxide) was white except for a thin green ring around the cup at the contact line. This color was the characteristic color of dissolved ferrous silicate. Enamel A with 5 per cent NiO after 3 hours heat treatment showed a beautiful and rather extensive dendritic growth of metal extending from the contact line about half way toward the center of the cup. Fig. 4 shows a photomicrograph of this specimen. This in all probability is metallic nickel. After the same heat treatment enamel A with 5 per cent CuO addition showed a well defined ring of metallic copper. Another sample of enamel A with a 5 per cent NiO addition was fired for 7½ hours. It was then polished and coated with a thin layer of pure gelatin and this allowed to dry. The specimen was then placed in a 4 per cent solution of acetic acid for a few seconds and removed to a solution of dimethyl glyoxime. The gelatin was used to prevent spreading of the color. The characteristic red color of nickel dimethyl glyoxime was deep and strong in the center of the cup but faded away evenly toward the contact line. Just at the contact line there was a distinct red ring, showing that the concentration of the nickel there had been appreciably increased. The interpretation would appear to be that the nickel ions in the glass near the contact had been reduced by the iron of the cup with the deposition of metallic nickel, but at the center of the cup, away from the iron, nickel ion concentration remained unchanged.

A somewhat similar experiment was made with the borosilicate glass which contained 4 per cent Co_3O_4. This composition was heated for periods up to 8 hours, after which photomicrographs were taken of the polished specimens. One of these photomicrographs is shown in Fig. 5. The metallic deposit is evident. A sample of *enamel* near the contact was tested for iron by use of potassium mercuric thiocyanate, giving red needles of the iron compound. Cobalt forms blue needles with this reagent. A sample of *metal* at the contact was tested with γ nitroso—β naphthol, which is a specific reagent for cobalt in presence of iron, and found to give a positive test, a distinct red precipitate. These tests indicate pretty clearly that an exchange reaction has taken place, the iron entering the glass phase and the cobalt being reduced to the metallic state.

This brief presentation of the chemical and metallographical tests lends strong support to the oxidation theory of metal-glass adherence. When oxides of cobalt, nickel and copper are dissolved in glass and brought into contact with metallic iron at a temperature where the glass can flow, the iron is oxidized and taken into solution while the cobalt, nickel or copper ion is reduced to the metallic state. Likewise, in making seals of tungsten into glass, best results are obtained when enough tungstic oxide is dissolved in the glass to give it a reddish brown color near the metal contact.

PROBLEMS FOR THE PRESENT AND FUTURE.

Recognizing that oxidation of the metal seems to be a necessary step towards getting good metal-glass seals, the problem arises as to how this may best be accomplished. If we had available a high temperature "electromotive series" of oxidation potentials of oxides dissolved in glass, it would be a comparatively easy matter to choose that sample which would oxidize any metal which we may wish to seal to glass. There is still a serious lack of ordinary dissociation pressure data on pure solid oxides at temperatures above 800°C. This information is needed for any systematic application of either method 1, 2 or 3. The determination of the exact state of oxidation of iron in ferrous-ferric glasses is one which is of considerable interest to makers of color screens, eye-protection glasses, etc., and represents the kind of fundamental information necessary in connection with metal-glass seals.

From the standpoint of the metallurgist, more information is needed as to both the magnitude and rate of oxygen adsorption by metals at high temperatures, and the structure of surface layers.

Laboratory information of the kind indicated herewith is very inexpensive as compared with large scale cut and try tests which prevail in many industrial organizations where brute force methods are foolishly considered equivalent if not actually superior to scientific insight. So long as the technical world gives support to its scientific work just so long will progress continue —and not so much by slow growth as by leaps and bounds. The glass industry has a great future before it and it is a future that will surely be realized by mutual cooperation with the colleges and universities which provide most of its fundamental data and principles.

---

[1] A. Hull and E. Burger. Phys. **5** 384-405 (1934).
[2] H. F. Staley, J. Am. Cer. Soc. **17** 163-167 (1934).
*This method of measurement of the change in shape of a silicate melt is due to Drs. E. P. Barrett and J. A. Taylor of the Mineral Industries Experiment Station, The Pennsylvania State College, to whom the writer is indebted.

AN IMPROVED SOFTENING POINT FURNACE

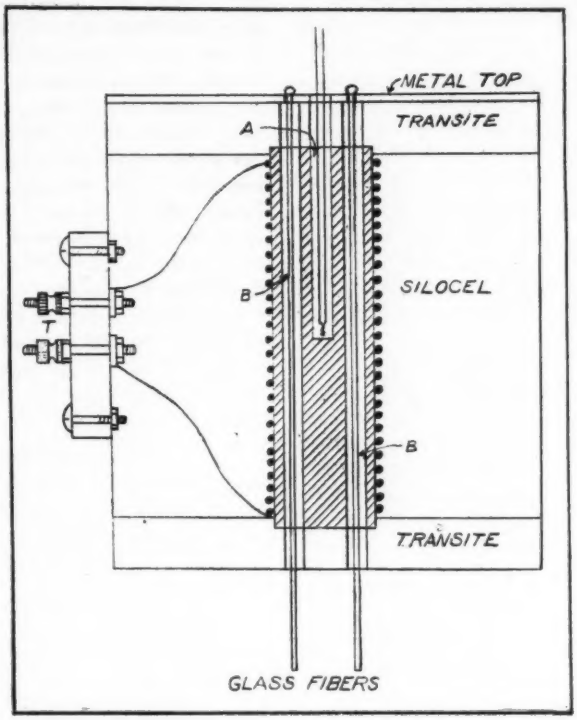
By C. L. BABCOCK
Purdue University

THE standard softening point apparatus in common use at the present time follows closely the design recommended by J. T. Littleton[1]. The furnace and its operation has also been completely described by D. E. Sharp and J. Bailey[2].

This furnace has a cast iron core with a small hole runnining through its axis. Another hole running half the length of the core holds the hot junction of a thermocouple. This design is not correct from the standpoint of thermal symmetry. H. R. Lillie[3] has recommended that a hole similar to the one holding the thermocouple be drilled from the other end of the core and diametrically opposite in order to overcome this difficulty. Only one glass may be tested at one time by this apparatus. It is assumed that the glass to be tested is subjected to conditions which are identical with those under which the standard is tested. This will be true only for short periods of time as the characteristics of the furnace slowly change with time. In case the softening point is determined regularly in the plant for the control of glass melts this, of course, limits the number of glasses to be tested in a given time. This same problem has come up in our glass course, in which the student has three hours to do an experiment.

With the above things in mind a furnace has been constructed and used which will measure the softening points of two glasses simultaneously. This makes it possible to test an unknown glass against a standard at the same time under similar conditions. In case a great number of glasses have to be tested regularly a test can be run of the standard glass, say each day, and then the other glasses can be tested just twice as fast.

The design is similar to that of Littleton except that the metal core has been completely changed. The core has a hole running through its axis half-way down, as shown at A, which holds the thermocouple. Thus the hot-junction of the thermocouple is located at the geometrical center of the core. Two small holes (B) diametrically opposite run through the full length of the core. The two glasses under investigation are drawn into standard size fibers and placed in the furnace as shown.



The metal core has been made of copper since its diffusivity is 1.133 while that of cast iron is only 0.121. This seems to be an important consideration since measurements are taken as the temperature is changing (5°C. per minute), and the heat conductivity varies as the square of the diffusivity.

This apparatus has been used to measure the softening points of glasses in the temperature range 600° to 800°C. and good results have been obtained. The glasses tested have included lead, soda - lime - silica and Pyrex. The method of taking measurements is quite similar to that used in the apparatus described by Littleton.

The furnace described has been constructed for use in the course, Physical Technology of Glass now being taught at Purdue. This is a cooperative course offered by the Physics Department (Head, K. Lark-Horovitz) and the Chemical Engineering Department (Head, J. L. Bray).

[1] J. T. Littleton, Jr., Journ. Am. Ceram. Soc., 10; 259-64; 1927.
[2] D. E. Sharp and J. Bailey, Glass Industry, 12; 179; 1931. Glass Industry, 14; 87; 1933.
[3] H. R. Lillie, Journ. Am. Ceram. Soc., 14; 504; 1931.

SOCIETY OF GLASS TECHNOLOGY

The final Ordinary Meeting of the Society of Glass Technology of this season was headed Liverpool, June 19. Papers were presented as follows: "A Method of Determining the Resistance of Refractory Materials to Slagging." By A. E. J. Vickers and R. A. Bell. "The Influence of Icon-Oxide, Carbon, Sulphur and Silerium in Coloring Soda-Lime-Silica Glasses." By A. Ally and Professor W. E. S. Turner. "The Decomposition of Sodium Nitrate and Its Reaction with Silica." By W. Maskill and Professor W. E. S. Turner. "The Influence of Carbon Dioxide on the Melting of Glass." By Professor M. A. Bisborodov and A. A. Sokolova and G. A. Shinke.

Dean M. E. Holmes of the New York State College of Ceramics has been elected president of the Wellsville (N. Y.) Rotary Club for the coming year.

OWENS PACKAGING LABORATORY

Owens-Illinois Glass Company will shortly erect a two story building at Toledo to house its Packaging Research Laboratory and certain other departments. The structure will be built entirely of glass block, insulated with glass wool and an air-conditioning system will make use of glass filters.

Net earnings of Owens-Illinois Glass Company and subsidiaries for the twelve months ending June 30 were $7,157,767 as compared with $5,854,212 for the corresponding period the previous year.

BUILDING SHOWS MARKED INCREASE

Building construction in New York City is going ahead at a pace not attained since 1931. One hundred new apartment houses are under construction, and 50 more are scheduled to be started before Fall. Single family residences are also showing splendid gains.

What is considered to be the world's largest piece of structural glass was installed recently in the Palazzo d' Italia, Rockefeller Center, New York. The panel was designed by Attilio Piccirilli, and cast at the Corning Glass Works under the supervision of Frederick Carder. A second panel of the same size will be installed later in the Summer.

L-O-F ACQUIRES VITROLITE CO.

Libbey-Owens-Ford Glass Company, Toledo, has acquired the Vitrolite Company, manufacturers of structural glass. The latter concern operates a factory at Parkersburg, W. Va., and maintains executive offices in Chicago. Hereafter it will be identified as The Vitrolite division of the Libbey-Owens-Ford Company.

Six hundred men and women attending the convention of the American Institute of Electrical Engineers at Cornell University, last month, spent the entire third day of their meeting inspecting the Corning Glass Works.

FOURCAULT TANKS

(*Continued from page* 240)

Keeping in mind the importance of thermal homogeneity to successful sheet production, a system of control could be worked out that would minimize changes in the glass currents and help to maintain the same temperature across the width of the drawing canal. Thus, perhaps, an improved quality of glass could be made on the tee-type tanks; these having the advantage of being much easier and more simple to operate from a machine standpoint than tanks whose machines are separately located around a relatively large drawing chamber.

FLOODS ENDANGER CORNING DISC

Flood waters from overflowing streams and rivers caused no end of concern at the Corning Glass Works last month. During the period when all of Western New York State was inundated by the unprecedented floods, water threatened to mar the annealing of the big 200 inch telescope disc. The water level is reported to have reached the window sills, but did not go further.

PUBLICATIONS

A Discussion of Thermal Spalling of Fire-Clay Brick with Relation to Young's Modulus of Electricity, Thermal Expansion and Strength. R. A. Heindl, Chief, Refractories Section, National Bureau of Standards. Technical Bulletin 58, May, 1935, of the American Refractories Institute.

A Filter for Obtaining Light at Wave Length 560 *Mu.* Kasson S. Gibson. Research Paper RP 785, National Bureau of Standards. A new 4-component glass filter has been designed, which isolates and transmits light at 560 mu more effectively than previous filters.

The New Density Comparator. Bausch & Lomb Optical Co., Rochester, N. Y. A bulletin describing a new instrument designed for accurate and rapid spectrographic analysis.

NEW USES FOR GLASS

One of the high spots of the recent Federal Housing Exposition at Los Angeles was this house, built almost entirely of glass by a prominent furniture manufacturer to serve as a merchandising vehicle for his goods. The demonstrator lived, ate and also slept in full view of the spectators, while a public address system carried her messages to throngs outside.

INTERNATIONAL TRADE IN GLASS

By CHARLES H. DUCOTE
Bureau of Foreign and Domestic Commerce

GLASS products in their many forms make up one of the important commodity groups in international trade. It is estimated that the total world interchange in such items during 1929 was something over $200,000,000, with about nine countries supplying almost all of the demand.

Following 1929, a decline set in in the exports of glass from these countries, reaching a low point during 1932 of $83,212,000. As may be seen from the accompanying table and other statistics, most of these countries shipped slightly more glass abroad during subsequent years, their export sales during 1934 having amounted in total to the equivalent of $123,557,000, on the basis of average exchange rates for the year. It is to be noted, however, that since 1932 many changes have occurred in currency exchange rates so that if we calculate the equivalent value in dollars of 1934 export trade of these countries on the basis of exchange rates in 1929, we obtain instead a figure of $87,147,000 as the total glass exports of the nine principal supplying countries. Nevertheless, on either basis of conversion, it would appear that world trade in glass has already passed the low point and is on the upgrade.

Germany Leads in Glass Exports

Although the foreign sales of German glass manufacturers have declined from year to year since 1929, along with the decline in general world trade, there has not been a great deal of variation in the German portion of the total world trade in these items. According to the data at hand, German firms have continued to obtain about a third of the total foreign trade in glass, which gives them the position of leadership in supplying foreign glass demand.

It has been estimated that the glass branch of German production in 1928 employed more than 100,000 persons, and the total value of production in that year was R.M. 430,000,000. Succeeding years have witnessed a decrease in output and employment and we find that during June, 1933, there were said to be 4,217 establishments in operation employing 57,781 workers. Based upon the number of persons engaged, the most important sections of the industry at that time were as follows: white hollow glass, 26,307 employees; working of flat glass, 7,500 employees; bottle industry, 7,439 employees; and production of flat glass, 5,661 employees.

Among the most important areas in the industry are Thuringia, with about 20% of the workers and producing mainly hollow glass such as tubes, vacuum bottles, funnels, globes, glass vessels of various kinds, optical glass, etc.; and Saxony, comprising about 15% of all glass workers in the country and producing principally plate and sheet glass, wire glass, hollow glass articles, and pressed glassware.

The industry made some progress during the last year and production and employment increased; output during 1934 was about 13% above the average production

INTERNATIONAL TRADE IN GLASS (EXPORTS)
(,000 omitted)

Country of Origin	1929			1932			1933			1934		
		A	B		A	B		A	B		A	B
Germany(R.M.)	247,340			123,370			120,045			106,485		
A.		58,870			29,360			28,570			25,343	
B.			58,870			29,360			36,458			41,955
Czecho. (Cr.)	1,378,039			611,266			531,262			597,000		
A.		40,790			18,093			15,725			17,671	
B.			40,790			18,093			20,188			25,312
Belgium (Fr.)	1,511,629			574,092			523,536			526,044		
A.		42,023			15,959			14,554			14,624	
B.			42,023			15,959			18,634			24,460
France (Fr.)	542,885			161,982			155,036			146,580		
A.		21,281			6,349			6,077			5,723	
B.			21,281			6,366			7,767			9,592
Un. King. (£)	2,268			1,265			1,263			1,439		
A.		11,023			6,151			6,140			6,993	
B.			11,023			4,437			5,329			7,253
Un. States ($)	10,931			4,067			4,306			5,743		
A.		10,931			4,067			4,306			5,743	
B.			10,931			4,067			4,306			5,743
Japan (Yen)	13,211			9,267			15,322			19,454		
A.		6,090			4,276			7,063			8,968	
B.			6,090			2,607			3,913			5,778
Netherl. (Fl.)	8,892			3,281			3,120			2,744		
A.		3,571			1,317			1,253			1,101	
B.			3,571			1,321			1,605			1,849
Italy (Lire)	40,643			19,536			18,804			18,864		
A.		2,113			1,015			978			981	
B.			2,113			1,022			1,254			1,615
Totals:—												
A.		196,692			86,587			84,666			87,147	
B.			196,692			83,212			99,454			123,557

Legend—A.—Equivalent values in $ at average annual 1929 exchange rate basis.
B.—Equivalent values in $ at average annual *actual* year's exchange rate basis.

during the preceding year. Domestic trade in nearly every month of the past year was better than in corresponding months of 1933, although trade in the individual branches of the industry fluctuated considerably. Improvement in the flat glass section was very satisfactory, largely due to the revival of building and construction and the increase in automobile production. The total production of flat glass in 1934 was estimated to have amounted to 20,000,000 square meters, a higher figure than that of any post war year except 1929, and representing a 50% increase over production in 1933. Prices of flat glass remained stationary during the year.

Export sales in 1934 declined about 12% of the 1933 figure so that total sales for the year were about 43% of the corresponding shipments during the boom year 1929. Among Germany's principal glass exports are optical glass and instruments of all kinds, hollow ware and pressed glass, and the principal foreign markets supplied by German glass are the United Kingdom, France, the Netherlands, Denmark, Japan, and almost all of the other countries of the world.

Perhaps the most interesting feature of the glass export situation during the year was the continuation of the expansion, which has been in progress since 1929 of the flat glass exports. The flat glass group was one of the very few which could show larger exports in the year during which German export trade sunk to levels not previously recorded since the beginning of the present century. The principal market for flat glass was the United Kingdom, followed by the Netherlands, Denmark, and Brazil. Importance of South American markets seems to be on the increase with Brazil leading in this movement.

Czechoslovakia Exports High Percentage

Glass making is one of the oldest Czechoslovak industries as the first glassworks of the country date back to the eleventh century. It is noteworthy also that usually from 75 to 80 per cent of the output of the 120 to 125 glass works is exported to foreign markets. Active foreign demand is necessary, therefore, for the prosperity of the Czechoslovak glass industry.

In recent years Czechoslovakia has maintained a position slightly in advance of Belgium as an important supplier of world demand for glass and handles in the neighborhood of 20% of total glass exports.

Following several years of decline, the year 1934 brought a moderate but very heartening improvement in the domestic and export trade. There are no data on the quantity of glass produced last year, however, an estimate of the slight progress made may be obtained by comparing the Maiwald index of activity for the glass industry which is compiled on the basis of indirect indicators, of 51.5 for the year 1934, with that for 1933, of 48.6. Notwithstanding the improvement in domestic and foreign sales only slightly more than half of the factories were in operation during 1934, and of the 40,000 to 50,000 workers in the industry approximately half were registered as unemployed at the year's end.

Export sales of Czechoslovak glass manufacturers showed a marked improvement in 1934 over those of the previous year, the figures showing a gain of more than 8 per cent in quantity and 12 per cent in value. Even with this improvement, however, 1934 sales were but 43 per cent of those in 1929. The reduction of the gold content of the crown early in the year was no doubt one of the principal factors favoring greater sales of Czechoslovak glass as it improved the competitive position of this glass in world markets.

With a few exceptions greater amounts of all classes of glass were exported last year; plate and sheet glass accounted for more than 19%, fine etched and cut hollow glass for 17%, buttons, corals, bangles, etc for 13%, and molded glass for 10%, of total exports.

Czechoslovak exports of glass go to practically all countries of the world but Great Britain, the United States and Germany in that order were principal consuming countries, absorbing 17%, 12%, and 12%, respectively of the total. Other important foreign purchasing countries were France, Italy and other European countries.

Belgium Exports Normally High

In normal times Belgian glass manufacturers are said to export more than 90 per cent of their total production. Obviously the industry is highly dependent upon world demand and, therefore, the depressed conditions in foreign countries have reacted to hold back recovery in the Belgian glass industry. The figures in our table show that while the Belgians formerly obtained about 21 per cent of the world trade in glass, during 1934 the proportion was between 19 and 20 per cent.

The production of flat glass is the principal activity of glass manufacturers and Belgium has been the principal window glass manufacturing and exporting country in the world. Window glass makes up by far the most important class of glass exports from Belgium, official statistics indicating that during the last few years something over 40 per cent of total exports were composed of window glass. The group "mirror glass and unframed mirrors" is the next most important, items within this classification comprising about 35 per cent of Belgian glass exports.

The year 1934 was very unsatisfactory with regard to the output which continued the downtrend begun in 1930 and the total for the year was only one-third of 1929 production. The industry worked during the year on an average of 30 per cent of capacity. It is estimated that window glass manufacturers during 1934 amounted to 24,500,000 square yards, compared with 73,750,000 square yards in 1929. The tremendous decrease is attributed not only to the world depression but also to the building of glass factories in several countries which used to be large buyers of Belgian glass.

Activity in the plate glass branch remained at about 40 per cent of capacity and production showed roughly the same decline since 1929 as in the window glass section, the actual figures being 4,565,000 square yards and 1,827,768 square yards, for 1929 and 1934, respectively.

Notwithstanding its reputation for quality of products, it will be difficult for the industry to regain its former prosperity, especially if new glass plants continue to be erected in foreign countries, thus cutting the demand for Belgian glass in these countries and injecting a further element of competition in other markets.

It is worthy of mention, however, that the recent devaluation of the franc favored the window glass industry somewhat. Domestic demand increased and absorbed

stocks of glass on hand, and production had to be stepped up. Prices were increased by 10 per cent. Official statistics for the first quarter of the present year show improvement over the same period of last year, in window glass exports. Conditions in the plate glass branch continued about on a level.

Among the principal foreign markets for Belgian glass are the United Kingdom, the Netherlands, France, Canada, Argentina, Japan, Morroco, and many others of less individual importance.

France Shows Greatest Decline Since 1929.

Although all of the principal glass exporting countries have experienced a decline in their sales since 1929, estimates of French glass exports indicate that sales abroad during 1934 were only about 27 per cent of the total for 1929, this being the largest decrease suffered by any of the major countries in this branch of the export trade. Also, the figures of the last few years would appear to indicate that instead of supplying as in the recent past more than 10 per cent of the international trade in glass, French firms have been obtaining from 2 to 3 per cent less of this business in the last three years.

The latest information at hand on the French industry shows that during 1933 operations were conducted at an overall average of about 50 per cent, although certain branches of the trade were less affected than others by the general business depression. The factories producing ordinary window glass which have an annual production capacity of 20,000,000 square meters worked at 50 per cent of their resources. In the face of restricted consumption bottle plants reported operations during the year as approximately two-thirds of capacity. Stemward manufacturers made little headway. This branch of the industry operated without trade agreements and regulations and suffered more than others. The number of workers employed during 1933 was estimated at 42,700 in contrast to 63,500 engaged in normal times.

As a whole, the French glass industry up to recent years has been in a favorable position as regards its export trade. Lately the raising of tariff walls, the devaluation of currencies, and the industrialization of certain importing countries have been important factors in curtailing this formerly larger and more profitable trade, while the home market has been contracted by decreased buying power and the inroads of glass products of foreign production.

Exports during 1934 are estimated to have been somewhat less in value than those of 1933. The most important groups shipped abroad were window glass, table and other glassware, glass containers, and plate glass. Sales were made principally to the French colonial possessions, United Kingdom, Belgium, Germany, Switzerland, and the Netherlands.

United Kingdom Ranks Among First in Glass Imports

Although not of first importance in glass export trade the United Kingdom is worthy of mention for the fact that it offers perhaps the principal market for the products of foreign glass producers. Imports during 1934 and 1933 amounted to £3,129,700 and £2,806,632, respectively, these figures being more than twice the value of exports of British glass during corresponding years. Exports of glass from the United Kingdom have not languished, however, last year having recovered to 63 per cent of the 1929 figure. British manufacturers have been handling from 6 to 8 per cent of the world's export trade in wares of glass.

There are no recent data on the extent of production and employment in the British industry. However, the information at hand indicates that the country is least dependent upon foreign sources for its needs in containers, sheet glass, automatic glassware, glass tubing and rod and scientific glassware; and most dependent upon foreign supplies of domestic and fancy glassware and illuminating glassware. It has been estimated that one-third of requirements are satisfied by foreign sources.

Official statistics show that over half of British exports are made up of plate and sheet glass, the majority of this material going to Empire countries. Other important export classes are glass containers, domestic and fancy glassware, glass and glassware not elsewhere specified, and scientific tubing and rod.

British imports of glass are divided into four main classifications: plate and sheet, comprising about 40 per cent of the total and imported mainly from Belgium; domestic and fancy glassware, making up about 35 per cent of the total, imported from Czechoslovakia, Germany and Belgium; illuminating glassware; and containers.

The glass industry in the United Kingdom experienced during 1934, as a whole, considerable advancement over the previous year, and conditions so far this year indicate that prospects are bright for the present year to be more satisfactory than the last.

United States Shows Second Best Export Trade Recovery From Depression Low

From the low point in 1932 of $4,067,000, American glass exports made, apart from those of Japan, the best recovery for any of the countries mentioned herein, experiencing a gain of 33 per cent. Foreign sales last year attained a value over 50 per cent of the total for 1929. Continuation of this progress in the export field will assure our manufacturers of at least retaining their proportion (about 5 per cent) of the total world trade in glass.

In the absence of official data as to the extent of the industry in 1934, it is worth noting that Bureau of the Census figures show a total value of products made in 1933, of $191,985,322, and of workers employed on the average of 49,763. While there is still much ground to be covered to reattain the production of $303,818,560 and employment of 67,527, corresponding to 1929, very substantial progress toward this end was made last year. Employment during the year hit a five year peak and exceeded the averages of every year since 1929. Manufacturers profits also regained much of the ground lost during the depression. It is encouraging to note that this betterment has continued into the present year.

Glass exports last year reached the highest figure since 1931, all of the classifications showing increases. The main groups exported were: other glassware, not separately classified; glass containers; plate glass, unsilvered; plain glass tableware; globes and shades; window glass, and chemical glassware. The most important markets for American glass were Canada, Cuba, Australia, Mexico, Japan, and the Philippine Islands. If pre-

liminary figures for the first few months of this year are indicative of the results for the entire twelve months, a new high will be made in 1935 sales abroad.

The import trade also increased, though not to the same extent as the exports of glass, and larger quantities were brought into the country of the principal groups figuring in our glass imports. The main classes were blown glass, except bulbs; glass containers; other glassware; scientific articles and utensils; and illuminating glassware. These products were supplied mainly by Germany, Czechoslovakia, France, Belgium, and the United Kingdom.

Japanese Exports in 1934 Greater Than 1929

While other countries have been watching their exports of glass decline in value during 1934, to but 27 per cent in the case of France, and 63 per cent for the United Kingdom, for example, of the totals corresponding to 1929, Japan actually exported last year glass valued at one and a half times the sales made during the boom year. Moreover, foreign sales last year showed an increase over 1933 of 4,132,000 yen, or 27 per cent. In the total international trade Japanese firms supplied something like 5 per cent of the demand figured on the basis of the average exchange rate for 1934.

An interesting summary of the glass industry in Japan was published in the Monthly Circular for July, 1934, of the Mitsubishi Economic Research Bureau, from which we note that production, as well as exports of glass, have been on a rising trend. The most important glass item manufactured in Japan, according to the Bureau, is sheet glass which accounts for about 40 per cent of the total value of glass produced, followed by glass containers, table glassware, and ornamental glassware. The article points out moreover, that sheet glass production during 1933 reached the figure of 2,856,000 cases (of 100 sq. ft.) an increase of about 30 per cent compared with the previous year, and estimates the output during 1934 at 3,500,000 cases. On the basis of these figures the claim is made that Japan stood in actual production in 1933, for the first time at the head of the sheet glass producing countries of the world. Production capacity is placed at 3,800,000 cases.

This rate of activity appears to have been maintained in recent months judging by the Japanese Department of Commerce and Industry monthly indices of plate glass production which show that on the basis of 1930 output as 100, the average index number for 1933 was 131, and for 1934 was 143. The Japanese plate glass industry is said to be as yet comparatively small, however, recently installed equipment should give it much greater importance and not only enable it more easily to displace imported glass, but make possible increased sales abroad as well. During the last three years Japanese imports of plate glass have averaged over 3,000,000 yen per year, this kind of glass being the most important glass import.

Japanese exports of glass during recent years have increased at a very rapid rate. Such sales during 1931 amounted to only 6,534,000 yen while in 1934 the total was almost three times as great. In the same period of time exports to the United States increased at an even greater rate, namely, from 100,000 yen to 1,816,000 yen. Principal countries purchasing Japanese glass in order of importance have been British India, Netherland India, the United States, China, Straits Settlements and Philippines. The important items of Japanese exports are vacuum and other bottles, glass cups, mirrors, window glass, spectacle lenses and frames, glass beads and balls, tableware and watch glasses. The most rapid growth is shown in the foreign sales of window glass, spectacle lenses, vacuum bottles, and tableware.

United States import figures concerning incoming shipments of glass from Japan show the same trend as those referred to above. Preliminary data show imports during 1934 to have amounted to $389,697 compared with $134,300 for 1933. Imports during the first two months of this year were valued at $83,408.

Italy and Netherlands of Minor Importance

Compared with the export trade obtained by glass manufacturers in the other European countries mentioned above the proportion of the total trade handled by Italian and Dutch firms is small indeed, each of these countries furnishing about 1.5 per cent. The glass industries in these countries are important enough, however, to warrant some mention as they supply a large domestic demand in addition to their comparatively small, but nevertheless substantial export trade.

According to a leading British glass technologist the glass industry in Italy is an important one and the country probably ranks sixth among the glass producing countries of Europe. The "Annuario delle Industria della Ceramica e del Vetro" states that there are 430 glass plants employing 27,613 workers, the division of employees in the industry being as follows: hollowware, including artistic glass, beads, illuminating and scientific glass 13,916; bottles 9,539; sheet, plate and stained glass 4,158. Perhaps the most interesting and widely known section of the industry is that situated in Murano which has been making for centuries a distinctive and variegated line of artistic glassware.

While Italian exports during 1934 showed almost no increase over the previous year, the low point reached in 1933 was down only to 45 per cent of the 1929 export total, less of a drop than was experienced by some of the other glass exporting countries. The principal classes in this branch of Italian export trade are lighting and household glassware, pressed and blown glassware, and miscellaneous cut, colored, etc. glassware. Most of the shipments of this ware were consigned to France, British India, United States and Egypt.

Although ranking high as a glass producing country Italy does not turn out sufficient glass to satisfy national requirements so that considerably more than twice as much glass has to be imported as is shipped out of the country. The Italian demand is composed mainly of the categories window and plate glass, about 60 per cent of which is supplied by Belgium, and the remainder by the United Kingdom, Germany and Czechoslovakia; pressed and blown glassware, imported to the extent of about 40 per cent each, of the total, from Czechoslovakia and Germany and the remainder from Austria, France and Belgium; and photographic plates and glass tubing.

The Netherlands export trade in glass products during the years of depression has been carried on under such difficulties that sales have declined from year to year to the point that the value of exports during 1934 was only 30 per cent of the glass sales abroad in 1929.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext. Per 100 lb.		...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	... Po. or Gr. / Cry.	.25 / .25½
Alcohol, denatured, 50 gal. drum	gal.	...	.56½
Aluminum hydrate (A1 $(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.10½
Antimony oxide (Sb_2O_3)	lb.	...	.12¼
Antimony sulphide (Sb_2S_3)	lb.	...	.11
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
" (Dehydrated)	In bags, lb.	.0372½	.0455-.0502½
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.		.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_2O_3) In bbls.	lb	...	1.39
In 10 lb. tins	lb.	...	1.49
Copper oxide Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08	.08½
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar— 20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	25.23	...
In bags	ton	26.83	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.	...	.0425
Black (Fe_3O_4)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.065	...
In 5 Ton lots	lb.	...	.07
Less than 5 Tons	lb.	...	.075
Lime— Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75-2.50	...
Litharge (PbO) (New York Prices)	lb.	.055	...
In 5 Ton lots	lb.	...	.06
Less than 5 Tons	lb.	...	.065
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0265
Manganese, Black Oxide In Paper bags	ton	45.00	50.00
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00 29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	...	.08¾
Powdered	lb.	...	.09¾
Potassium carbonate Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅜
Hydrated 80-85%	lb.	.06	.06¼-.06⅜
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.	..	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.18¾
Powder blue	lb.	...	.17-.18
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	... Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%— Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.06½
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¾	.05¼
Sodium hydrate (NaOH) (caustic soda) Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97% Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) . in bbls.	lb.	...	.39
Tin oxide (SnO_2) in bbls.	lb.	...	.54
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO) American process, Bags	lb.	.0575	.06
White Seal, 150 lb. bbls.	lb.	.10½	.10¾
Green Seal bags	lb.	.09¾	.09¾
Red Seal, bags	lb.	.08¾	.08¾
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04-.0[illegible]

EQUIPMENT AND SUPPLIES

ANNOUNCE IMPROVED DRIVE FOR CONTROL PYROMETER

For installations where their Potentiometer Control Pyrometers are to be used singly, The Foxboro Company, Foxboro, Mass., have developed an improved type of motor drive unit, called the "Type H." This drive comprises a ball bearing enclosed motor and a double worm and gear speed reducing system packed in lubricant.

In addition to its availability for single-controller installations this drive is amply powerful to operate one additional Controller, through a coupling between the Controllers. Although first quality construction is evident throughout the design and construction of this drive, it is offered at a considerable reduction in investment.

A new Bulletin No. 202 gives complete details regarding Foxboro Potentiometer Controllers and includes a description of this new drive unit for single Controller installations. Copy will be sent on request.

LATE NEWS

Thatcher Manufacturing Company, Elmira, N. Y., has purchased the Olean Glass Company, Olean, N. Y. The Olean factory will continue its own identity. W. D. Dugan, former general manager and secretary will be president, with H. C. Manderville and R. W. Niver, vice presidents. The purchase by Thatcher is reported to be "for investment only," and gives that company an interest in glass containers for foods, beverages, proprietaries, etc., besides milk.

●

Conrad J. Gundlach, Chairman of the Board of the Mississippi Glass Company, died at St. Vincent's Hospital, New York, on July 27. Mr. Gundlach went to the hospital just four days before his death. He was not feeling well and decided to go there for observation.

●

The Michel-Meier Decorating Company informs The GLASS INDUSTRY that reports to the effect they are about to take over the Rochester, Pa. factory of the H. C. Fry Glass Company are without foundation.

James T. Sultiff has been transferred from the factory to the Chicago offices of the Roots-Connersville Blower Corp., at 20 North Wacker Drive, where he will specialize on the sale of turbine pumps and Victor-Acme Blowers.

CATALOGS RECEIVED

Air Operated Combustion Control. Bulletin 102. Bailey Meter Company, Cleveland. A 32 page bulletin describing a complete combustion control system which automatically maintains steam pressure, combustion efficiency and furnace draft. Diagrams and photographs.

The Brush Phase of Motor Maintenance. The Ohio Carbon Co., Lakewood, O. A second edition, revised, with illustrations showing the company's testing system.

Spray Painting. Binks Manufacturing Company, Chicago. A 16 page, loose-leaf catalog of equipment and accessories. A chart explains the correct noggle set-ups to be used with different spray materials, and the correct air pressure and amounts of air needed, all charted.

Industrial Compressors and Vacuum Pumps, Type 30. Ingersoll-Rand Company, 11 Broadway, New York. A profusely illustrated catalog of 32 pages covering the I-R line of Type 30 industrial compressors and vacuum pumps from ¼ to 15 h.p., pressures up to 1000 pounds. Numerous industrial applications are listed and illustrated. Tables of sizes and capacities are included. Ask for Catalog 7502-D.

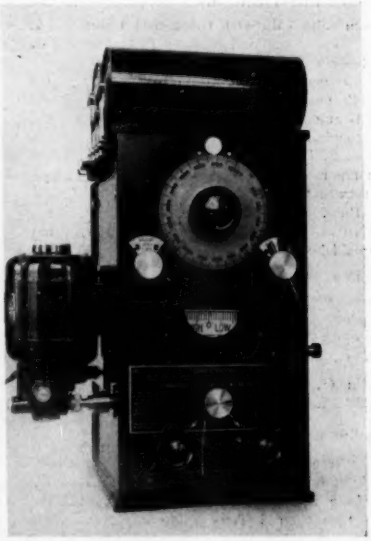
Type XPV Steam Driven Compressors. Ingersoll-Rand Company, 11 Broadway, New York. 48 pages, illustrated. Describing the new steam driven compressor, of the so-called four-corner construction, which permits any arrangement of steam and air cylinders. It is of the horizontal, duplex, double-acting, double-crosshead and tie-rod type, to run at moderate speeds and for heavy duty, continuous service. Sizes from 50 to 1500 h.p.

Microscope Accessories. Bausch & Lomb Optical Co., New York. A 64 page catalog. Descriptions and illustrations of the company's complete line, including price lists.

Cable Accessories. GEA-1839. General Electric Co., Schenectady, N. Y. 80 pages, liberally illustrated, listing and describing all the materials required for making cable joints, and price lists. Instructions are given for splicing, jointing and terminating all types of insulated cable.

LARGE FIELD POLARISCOPE

Simpson Foundry & Engineering Company, Newark, O., is now making generally available its new Large Field Polariscope, a radical departure from conventional designs. The manufacturers state this apparatus incorporates the very latest improvements for obtaining maximum sensitivity. In addition to its sensitivity it has two outstanding features: The large field of view available for inspection, and the relative freedom of motion for the observer's eyes over an extended area. This polariscope does not require a dark room, and the intensity of illumination is great enough to obviate the use of shields and curtains. The polarizer and the analyzer are built into the instrument, and no accessories of any kind are required. In addition to crystal, many tints and colored glasses may be tested.



MOVE YOUR GLASS FACTORY TO CHEAP FUEL, CHEAP GLASS SAND AND TIDEWATER

Largest gas reserves in Texas, near large city on tidewater. Ideal living conditions. Desire to cooperate with competent glass and tile manufacturer in financing a large plant to manufacture all kinds of glass, including bottles, plateware, tableware, etc.
Our proposition will interest you. Investigate.
F. C. Stevenson, P. O. Box 1801, Fort Worth, Texas.

Keep informed of the latest developments in the glass manufacturing field—equipment, materials, methods, important events, all are discussed in

The GLASS INDUSTRY

One year's subscription $2.00

BOTTLES

FULL AUTOMATIC MACHINE PROCESS

Whitall Tatum Company

Manufacturers Since 1836

Philadelphia New York

FACTORIES: MILLVILLE, N. J.

MIN-OX

RESISTS SCALE

Regarding Moulds . . . . . .

Users of MIN-OX say:

BRILLIANCY of the glass is increased.

FIRE FINISHING can be eliminated.

CLEANING of moulds is reduced.

You, too, should use MIN-OX.

MIN-OX Castings:—a series of alloys to meet varying glass production requirements.

THE BINNEY CASTINGS COMPANY

Toledo, Ohio

Originators Of Alloys For Glass Moulds.

for all types of glass decoration

GLASS COLORS ENAMELS ICES

FOR 65 YEARS

Specialists in Colors, Metallic Oxides and Chemicals for the GLASS INDUSTRY

METALLIC OXIDES AND CHEMICALS

Alumina
Antimony
Arsenic
Barium Carbonate
Bone Ash
Boracic Acid
Borax
Cadmium Carbonate
Cadmium Oxide
Cadmium Sulphide
Cerium Hydrate
Chrome Oxide Green
Cobalt Oxide Black
Copper Carbonate
Copper Oxides
Glass Decolorizers
Iron Chromate
Iron Oxides
Iron Sulphide
Lead Chromates
Lepidolite
Manganese Carbonate
Manganese Dioxide
Magnesium Carbonate
Neodymium Oxalate
Nickel Carbonate
Nickel Oxides
Nickel Sulphate
Polishing Rouges
Potassium Bichromate
Potassium Carbonate
Potassium Chromate
Powder Blue
Putty Powders
Rutile Powdered
Selenium
Sodium Bichromate
Sodium Selenite
Sodium Silico Fluoride
Sodium Uranate
Titanuim Oxide
Uranium Oxide
Whiting
Zinc Oxides
Zirconium Oxide

GOLD . . . SILVER . . . PLATINUM LUSTRE PREPARATIONS
Printing Tissues—Etching Supplies—Oils—Mediums—Banding Wheels —Brushes—Pallette Knives—Perfection Portable Decorating Kilns—Silk Bolting Cloth—Spraying Equipment—Grinding Mills.

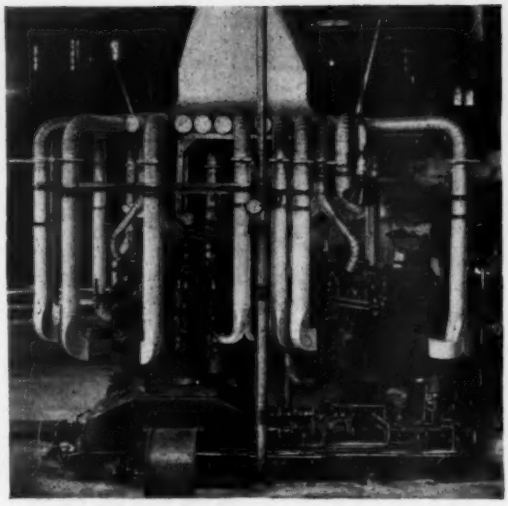
ESTABLISHED 1869

B. F. DRAKENFELD & CO. INC.

45-47 PARK PLACE, NEW YORK, N. Y.

BRANCHES: East Liverpool, Ohio . . Chicago, Ill. . . WORKS: Washington, Pa. PACIFIC COAST AGENTS: Braun Corp., Ltd., Los Angeles . . Braun-Knecht-Heimann Co., Ltd., San Francisco.

CUT COOLING COSTS



K & B wind system blowing cool air on the new No. 10 Lynch Bottle Machine at the Maryland Glass Co., Baltimore, Md.

KIRK & BLUM Blower Systems

Standard Equipment In Leading Glass Plants Throughout the World

Kirk & Blum Cooling Systems perform with greater dependability of operation, lower maintenance cost and much lower power cost. For example, in the first Kirk & Blum job at the plant of the Winslow Glass Co., Columbus, Ohio, we reduced the power from 45 h.p. to 20 h.p. with greater delivery of air. Since then several more installations have been made in the same plant.

Let K & B engineers plan a system for your plant that will adequately supply cool air to molds, machines, furnaces and operators with minimum power cost. Complete information and consultation without obligation. Write

THE KIRK & BLUM MFG. CO.,
2804 Spring Grove Ave. Cincinnati, Ohio

Chicago Office: 3843 N. Central Park Ave.
Detroit Representative:
D. H. Baird Company, 9143 Central Ave.
Pittsburgh Representative:
The Bushnell Machinery Co., 1501 Grant Bldg.
Louisville Representative:
Liberty Blow Pipe Company, Inc., 325 Roland St.

Hydrated
CARBONATE OF POTASH
83/85%
Manufactured now at Niagara Falls, N. Y.

A *New Domestic* product now made in *Crystals*, of uniform quality, especially for the Glass Industry.
Delivered in 400 lb. Barrels.
Generous samples sent on request.

JOSEPH TURNER & COMPANY
500 Fifth Ave., New York, N. Y.
Suppliers of Chemicals for over 70 years

MADE IN U.S.A.

BORAX
AND
BORIC ACID
Twenty-Mule-Team Brand

Guaranteed 99½% to 100% Pure

Makes Glass More Durable and Resistant

Free Booklet on Request
"BORIC OXIDE AS A CONSTITUENT OF GLASS"

Pacific Coast Borax Company
Department G
51 Madison Avenue, NEW YORK, N. Y.

20 MULE TEAM

EMILITE

Mould and Plunger Iron

LONGER LIFE—BETTER WARE

Analysis to Suit Your Individual Problem

All Inquiries Receive Prompt Attention

THE MILLER FOUNDRY CO.

730 SHELDON AVE. COLUMBUS, OHIO

"CONTROLLED LUMINOUS FLAME"

(Pat. Pending)

This advanced method of firing natural gas can be installed in your regenerator, recuperator or pot furnace.

Now in its 4th year of successful operation

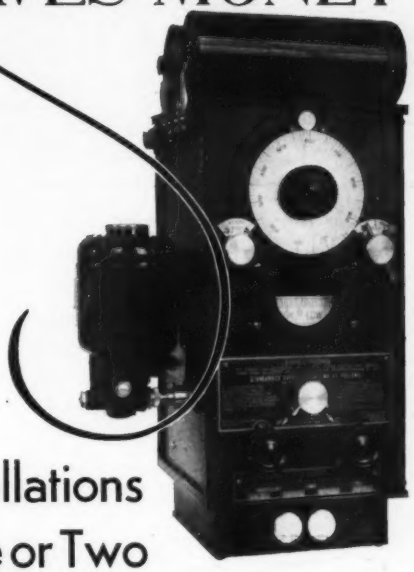
Combined systems now producing over 500 tons of glass per day.

THE TOLEDO ENGINEERING COMPANY, INC.

958 Wall Street Toledo, Ohio

GLASS PLANT ENGINEERS

NEW DRIVE SAVES MONEY



In Installations of One or Two FOXBORO CONTROLLERS

Lower investment without lowering of quality is achieved by this new "Type H" Drive Unit for Foxboro Potentiometer Controllers. It is used where only one Controller is to be installed—but it is amply powerful to drive one additional Controller with equal ease. The ball bearing enclosed motor, and the double worm and gear speed-reducing system packed in lubricant, make up a drive of outstanding strength and endurance. The Instrument is unchanged—it's the same simple, reliable Controller you've known for years.

Group Drive Saves 20%

Where two or more Controllers can be grouped, the group drive feature of Foxboro Controllers gives greatest investment economy as well as best efficiency. After the first Controller, there is a 20% saving on each additional Controller. Also, there's less maintenance on one motor than on many!

NEW BULLETIN 202

gives full details. Send for your copy.

THE FOXBORO COMPANY

34 Neponset Avenue Foxboro, Mass., U. S. A.

POTENTIOMETERS
Indicating
Recording
Controlling
MILLIVOLTMETERS
Indicating
Recording
ELECTRIC RESISTANCE THERMOMETERS
Indicating
Recording
Controlling

FOXBORO PYROMETERS

• THE FOXBORO COMPANY • FOXBORO, MASS. •

THE OTTAWA SILICA COMPANY

OTTAWA, ILLINOIS

ETERNAL AS THE SANDS OF TIME

The PRINCE of GLASS SANDS

The famous OTTAWA WHITE SAND

THREE PLANTS TO SERVE YOU

OPERATING YEAR AROUND

CRYSTAL SILICA 99⅝% PURE

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING ENGINEERS

FOR THE GLASS INDUSTRY

LANCASTER, OHIO U. S. A.

GUNITE CASTINGS *for the* GLASS INDUSTRY

GUNITE FOUNDRIES CORPORATION

GLASS SPECIALTIES

Transparent Colored Blown Sheet Glass
Solid Pot Opal Blown Sheet Glass
Flashed Opal Blown Sheet Glass
Colonial Antique Colored Glass
Heat-Ray Resisting (Cool Glass)
"TWIN-RAY"—
the scientific
illuminating
glass.

HOUZEX

L. J. HOUZE CONVEX GLASS CO.
Point Marion, Penna.
New York Office: 110 West 40th St.
Chicago Office: 1597 Merchandise Mart
"IF IT'S MADE OF GLASS, ASK US FIRST"

BAILEY & SHARP CO.
INCORPORATED

CONSULTING ENGINEERS

GLASS TECHNOLOGISTS

CABLE ADDRESS "SHARPGLASS"

HAMBURG, N. Y. U. S. A.

Follow the leaders—use—

SUPERFLUX BLOCKS

A LACLEDE-CHRISTY PRODUCT

SAINT LOUIS, MO.

Let us tell you about the

NEW DOMESTIC

ISCO CARBONATE OF POTASH

Calcined 96/98%
Hydrated 83/85%

Special Glassmakers Grades now made at Niagara Falls

INNIS, SPEIDEN & CO.
INCORPORATED
117-119 LIBERTY STREET, NEW YORK.

Chicago Cleveland Gloversville Boston Philadelphia

ISCO CHEMICALS

Good Books
for the Glassman

In answer to many requests for books relating to glass and its manufacture THE GLASS INDUSTRY presents the following selection of interesting and informative works.

Defects in Glass By C. J. Peddle	$2.25
Electrical Properties of Glass By J. T. Littleton and G. Morey	3.00
Glass By Percival Marston	1.00
Ceramics (a handbook) By A. Malinowsky	3.00
Ceramic Tests and Calculations By Prof. A. I. Andrews	2.25
Decorative Glass Processes By A. L. Duthrie	3.00
Industrial Furnaces (Vol. 1)	6.00
Industrial Furnaces (Vol. 2) By W. Tri-ks	5.50
Fuels and Their Combustion By Haslam and Russell	7.50
Industrial Stoichiometry By W. K. Lewis and A. H. Radasch	2.50
Non-Metallic Minerals By R. B. Ladoo	6.00
Refractories By F. H. Norton	6.00
Silica and Silicates By J. A. Audley	5.00

Send remittance with your order, or if you prefer, C.O.D. instructions. Prices quoted on foreign books are subject to exchange fluctuations.

The Glass Industry
Woolworth Bldg. New York City

TAYLOR REFRACTORY INSULATING BRICK

Gives REORDER Satisfaction

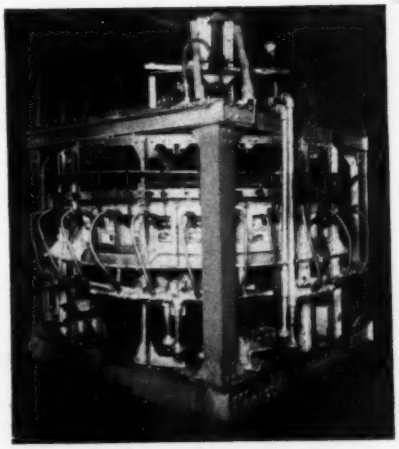


Illustration at the left shows a Continental Fire Glazer, used for automatic glazing of all kinds of glassware. The furnace has a maximum capacity of 120 tumblers per minute, and performs the operation of glazing the sides and top edges of the glassware. Taylor Refractory Insulating Brick, faced with P. B. Sillimanite Air-Setting Cement, is used to form all the combustion chambers in this furnace, and the brick is performing excellently.

The operating temperatures of this furnace vary in zones, the highest of which is about 1500 degrees F. As proof of entire satisfaction, the owner has purchased a second furnace in which Taylor Refractory Insulating Brick and P. B. Sillimanite Air-Setting Cement are used.

Tell our Engineering Department what you wish to accomplish. Probably we may offer some profitable suggestions. Ask for a copy of the booklet "Refractory Insulating Brick."

THE CHAS. TAYLOR SONS CO.
CINCINNATI, OHIO

PENETRATION

SUCCESS in marketing your product or service in the glass manufacturing field depends largely upon complete coverage of the industry.

PERSONAL contact is always the most effective method of selling but physical limitations make thorough penetration impossible . . . planned advertising, however, in THE GLASS INDUSTRY does accomplish this.

EDITED exclusively for glass plant executives THE GLASS INDUSTRY offers complete penetration of the field. It goes down byways as well as highways and carries a message to all companies and their executives, who either buy or influence buying of equipment, supplies, raw materials or service.

IT WILL supplement and support your personal selling . . . it will develop new outlets for you.

May we send you detailed facts?

The Glass Industry

233 Broadway New York City